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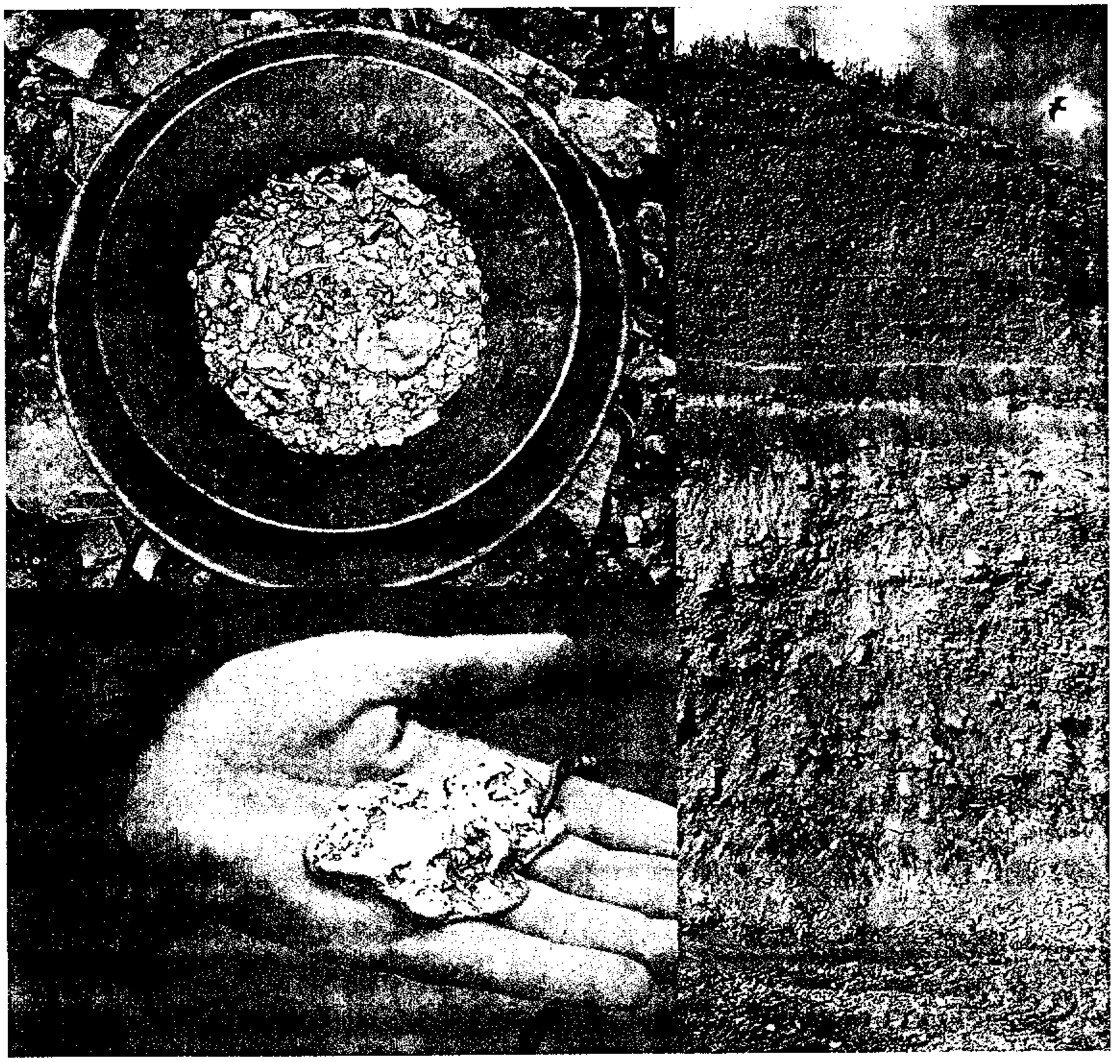

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Cover photos:
Lower left: Ten oz. gold nugget recovered from Empire Creek, 20 km. south of Mayo.
Upper left: Coarse gold from the Mayo area
Right: Mining exposure on Duncan Creek. The coarse boulder gravel on bedrock is a Reid age glaciofluvial outwash with placer gold values.

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EXPLORATION AND GEOLOGICAL SERVICES DIVISION
YUKON REGION

YUKON QUATERNARY GEOLOGY
VOLUME 2
1997

PREFACE

This volume is the second in a series of publications which document recent research in glacial history, surficial geology, geomorphology, placer geology, placer mining and mine reclaimation in the Yukon. These studies could not have been completed without the cooperation and support of local prospectors, placer miners and mining companies. This publication will assist them in discovering and developing new placer resources. Those interested in the environmental sciences and the Quaternary history of the Yukon will also find valuable information within.

Thanks to Charlie Roots and Bill LeBarge for their editing, and to the authors for their important contributions.

J.G. Abbott
A/Chief Geologist
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Northern Affairs Program
Yukon Region

PRÉFACE

Le présent volume est le second d'une série de publications décrivant les recherches récentes sur l'histoire glaciaire, la géologie de surface, la géomorphologie, la géologie des placers et leur exploitation ainsi que la restauration des mines au Yukon. Ces études n'auraient pu être menées à bien sans la coopération et le soutien des prospecteurs, des exploitants de placers et des sociétés minières du Yukon. Cette publication les aidera à découvrir et à mettre en valeur de nouvelles ressources placériennes. Ceux qui s'intéressent aux sciences environnementales et à l'histoire quaternaire du Yukon y trouveront également des renseignements utiles.

Nous remercions Charlie Roots et Bill LeBarge pour leurs travaux de révision ainsi que les auteurs pour leurs importantes contributions.

J.G. Abbott
A/Géologue en chef
Division des services géologiques et d'exploration
Programme des Affaires du Nord
Région du Yukon

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Overview of Yukon Placer Geology, Gold Production and Prospects

William P. LeBarge[1]

LEBARGE, W.P. 1997. Overview of Yukon Placer Geology, Gold Production and Prospects, In: LeBarge, W.P. and Roots, C.F., (editors). 1997. Yukon Quaternary Geology Volume 2, Exploration and Geological Services Division, Northern Affairs Program, Yukon Region, p.1-9.

ABSTRACT

The physiography and glacial history of Yukon bear directly on the geological setting, grade and economic viability of Yukon placer deposits. The limits of several advances of the Cordilleran Ice Sheet are evident in south central Yukon in the form of deposits and ice-marginal features left successively southeast by retreat of the three main glacial episodes.

The oldest, including multiple glaciations, was the pre-Reid at up to 3 Ma, succeeded by the Reid at up to 200 Ka, and the McConnell which ended approximately 10.3 Ka.

Yukon placer deposits are grouped into five broad categories based on age, geomorphic and sedimentologic characteristics. These are: 1) Pliocene to early Pleistocene alluvial placer deposits preserved as high level terraces buried beneath non-auriferous overburden; 2) Pleistocene non-glacial alluvial placer deposits that occur as valley-bottom fill and low to high level terraces in unglaciated terrain; 3) Interglacial placer deposits that occur as valley-bottom alluvial fill or low terraces in drainages that have escaped the effects of glacial erosion; 4) Glacial placer deposits that have formed when gold from regional bedrock or paleoplacer sources was incorporated into glacial drift; and 5) Recent placer deposits that are found as colluvial deposits, valley-bottom alluvial blankets in gulches and tributary valleys, bar deposits in major river systems and beach and nearshore marine deposits.

Ten major regions produce placer gold in Yukon: Indian River, Klondike; west Yukon (Sixtymile/Fortymile/Moosehorn); Lower Stewart; Clear Creek; Mayo; Dawson Range; Kluane; Livingstone and Whitehorse South. Since 1886, these areas have produced over 15 million crude ounces of placer gold, mainly from the unglaciated Klondike, west Yukon and Lower Stewart regions.

Many areas in Yukon remain unexplored for new placer gold deposits, both in unglaciated and glaciated areas. Areas of exploration potential in unglaciated areas include abandoned channels, oxbows and point bars, high level terraces, and tributary gulch and creek placers. In and along the margins of glaciated areas, pre-glacial or interglacial placer deposits may lie buried by glacial and glaciofluvial drift. Lower-grade placer deposits may have formed by glaciofluvial reworking of pre-glacial or interglacial placers. Non-glacial placer deposits may be found unconformably overlying glacial drift. Deeply incised interglacial valleys oriented obliquely to paleo-ice flow directions are also favorable locations for the preservation of economic placer deposits in glaciated areas.

Interest in exploring for new gold reserves has been sparked by new placer research and surficial mapping programs initiated by the Yukon Geology Program and the Geological Survey of Canada. As this research continues to add to the understanding of placer gold deposits, exploration activity is expected to continue and new reserves in both unglaciated and glaciated areas may be found.

RÉSUMÉ

La physiographie et l'histoire glaciaire du Yukon influent directement sur le cadre géologique, la teneur et la viabilité économique des gîtes placériens du Yukon. Les limites de plusieurs avancées de l'Inlandsis de la Cordillère se manifestent dans le centre-sud du Yukon sous forme de dépôts et de formes de relief proglaciaires déposés successivement vers le sud-est au cours du retrait des trois principaux épisodes glaciaires.

Le plus ancien épisode, à glaciations multiples, est l'épisode pré-Reid, daté jusqu'à 3 Ma, suivi de l'épisode Reid, daté jusqu'à 200 Ka, et de l'épisode McConnell, qui s'est terminé il y a environ 10,3 Ka.

[1] Exploration and Geological Services Division, Northern Affairs Program, Indian and Northern Affairs Canada, #345-300 Main St., Whitehorse, Yukon Y1A 2B5.

Les gîtes placériens du Yukon se divisent en cinq grandes catégories selon l'âge et les caractéristiques géomorphologiques et sédimentologiques. Ce sont : 1) les gîtes placériens alluviaux datant du Pliocène au début du Pléistocène et conservés sous forme de terrasses élevées recouvertes de morts-terrains non aurifères; 2) les gîtes placériens alluviaux non glaciaires pléistocènes se présentant sous forme de remplissages de fond de vallée et de terrasses basses à élevées en terrain non englacé; 3) les gîtes placériens interglaciaires se présentant sous forme de remplissages alluviaux de fond de vallée ou de basses terrasses dans des bassins versants ayant échappé aux effets de l'érosion glaciaire; 4) les gîtes placériens glaciaires formés par incorporation de l'or provenant du substratum régional ou de sources paléoplacériennes à des dépôts glaciaires; et 5) les dépôts placériens récents apparaissant sous forme de dépôts colluviaux, de couvertures alluviales de fond de vallée dans des ravins et des vallées tributaires, de dépôts de barre dans les principaux systèmes hydrographiques et de dépôts marins de plage et de littoral.

On compte dix régions aurifères principales au Yukon : la rivière Indian; le Klondike; le Yukon de l'Ouest (Sixtymile/Fortymile/Moosehorn); le cours inférieur de la Stewart; le ruisseau Clear; Mayo; le chaînon Dawson; Kluane; Livingstone; et Whitehorse sud. Depuis 1886, ces régions ont produit plus de 15 millions d'onces brutes d'or placérien provenant essentiellement des régions non englacées du Klondike, du Yukon de l'Ouest et du cours inférieur de la Stewart.

De nombreuses régions du Yukon, englacées ou non, restent inexplorées quant à la recherche de nouveaux gîtes aurifères placériens. Parmi les formes de relief présentant un potentiel d'exploration figurent les chenaux abandonnés, les méandres abandonnés et les dépôts de rive convexe, les terrasses élevées et les placers de ravins et de ruisseaux tributaires. Dans les régions englacées et en bordure de celles-ci, des gîtes placériens préglaciaires ou interglaciaires gisent peut-être enfouis sous des dépots glaciaires et fluvioglaciaires. Des gîtes placériens de basse teneur ont pu se former par remaniement fluvioglaciaire de placers préglaciaires ou interglaciaires, et des gîtes placériens non glaciaires reposent peut-être en discordance sur des dépôts glaciaires. Les vallées interglaciaires profondément encaissées et orientées obliquement par rapport aux anciennes directions d'écoulement glaciaire constituent également des emplacements favorables à la conservation de gîtes placériens rentables en région englacée.

Le regain d'intérêt pour l'exploration de nouvelles réserves d'or a été déclenché par de nouveaux programmes de recherche de placers et de cartographie de surface mis sur pied dans le cadre du Yukon Geology Program (programme d'étude de la géologie du Yukon) et par la Commission géologique du Canada. On s'attend à ce que se poursuive l'activité d'exploration à mesure que ces recherches continueront à alimenter notre compréhension des gîtes aurifères placériens, rendant ainsi possible la découverte de nouvelles réserves en régions englacées et non englacées.

INTRODUCTION

Although each placer gold deposit in Yukon is unique and they range in age from late Tertiary to Recent, it is possible to characterize them in five geological settings, based upon their physiographic setting and glacial history. Ten major mining areas have produced placer gold, both in unglaciated and glaciated regions. The placer gold production statistics reviewed in this paper are from an internal report by Leo van Kalsbeek, Mining Inspector, Mining Inspection Division, Northern Affairs Program. This paper is intended as a brief summary of the geological settings, available production values and future prospects for placer deposit reserves throughout the Yukon.

GEOLOGY OF YUKON PLACER DEPOSITS

Physiography and Glacial History of Yukon

Topography and geomorphology distinguish the main physiographic subdivisions in Yukon Territory (Bostock, 1966; Mathews, 1989).

Central and southern Yukon are dominated by the Yukon Plateau, which is bounded by the Selwyn Mountains to the northeast and the St. Elias Mountains to the southwest. The St. Elias Mountains are the most recently and extensively uplifted area in Yukon, with peaks to 5858 m at Mt. Logan.

The Yukon Plateau consists of several subdivisions, including the Klondike, Stewart, Lewes, Kluane, Teslin and Nisutlin plateaus. Two major linear valleys transect the plateaus forming graben structures along zones of pervasive strike-slip faulting; the Tintina trench (Tintina Fault) to the northeast and the Shakwak trench (Denali Fault) to the southwest. Plateau areas in central and southern Yukon were extensively weathered and eroded during the Tertiary prior to the onset of Pleistocene glaciations (Tempelman-Kluit, 1980).

Although a large part of central and northern Yukon escaped glaciation, the limits of several advances of the Cordilleran Ice Sheet are evident in south central Yukon in the form of successively southeasterly situated glacial deposits and ice marginal features (Fig.1). Near the limits of the ice advances, the tops of many plateaus stood above the ice sheet, especially during the last glaciation (Hughes et al., 1972). Unglaciated portions of the plateaus are characterized by deep, narrow valleys separated by long, smooth ridges of uniform elevation. Broad sediment-filled valleys, underfit streams and rolling, smoothly rounded hills characterize glaciated portions of the plateaus.

There were several major glacial episodes during the Pleistocene, and these have been categorized by age into three groups. Multiple glaciations occurred prior to the Wisconsin, and these, known as the pre-Reid, are older than 1.4 Ma (million years ago) (Duk-Rodkin et al, 1995; Duk-Rodkin and Froese, 1995) and may be as old as 3 Ma (Duk-Rodkin, pers. comm.). A less-extensive intermediate glaciation, known as the Reid, occurred more than

200 Ka (thousand years ago) (Berger, 1994). The last glaciation, known as the McConnell, began less than 29 Ka and ended approximately 10.3 Ka (Hughes et al., 1989).

Formation and Preservation of Placer Deposits

Placer deposits generally form during preglacial or long interglacial periods when sediment input has stabilized and fluvial action is able to rework heavy minerals distributed throughout alluvium into a mineable concentration on the bedrock floor. In addition warm preglacial or interglacial climatic conditions enable the weathering of bedrock, thus creating a supply of gold (if present) for eventual deposition into a placer deposit.

Glacial episodes bring changes in the variety and amount of sediment input, base-level and fluvial discharge. Stream courses may be diverted or reversed during glaciation. Post-glacial incision, a result of increased fluvial discharge and changing base-level, may result in remnant alluvial terraces and abandoned channels. After

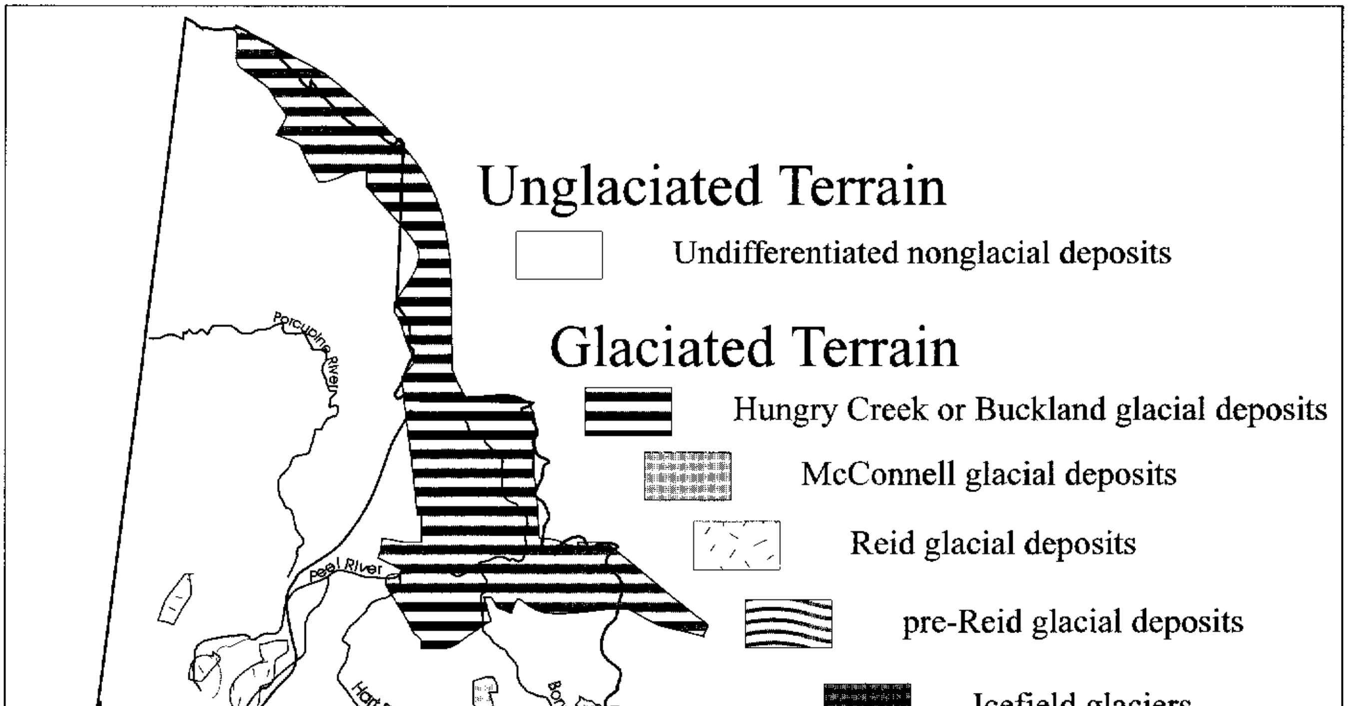

Figure 1. *Extent of Cordilleran glacial deposits in the Yukon.*

abandonment, alluvial terrace surfaces are subject to erosion and burial by colluvial processes, or, near the margins of glaciations, burial and reworking by glacial and glaciofluvial action. Placer deposits are best preserved either in unglaciated areas or distal to the ice sheet where depositional processes dominate and burial is more likely than erosion.

In rare instances, glacial and glaciofluvial deposits may contain significant amounts of placer gold. This usually occurs when ice-sheet meltwaters rework a previously-rich alluvial placer into a lower grade glaciofluvial deposit. Gold may occur in till when advancing ice erodes a pre-existing placer deposit or regolith, incorporating it into its sediment load. If transport distance is small (as in the case of an alpine or cirque glacier), the placer gold may remain undispersed and in a concentration near bedrock. Subglacial meltwater may also help to reconcentrate placer gold at the bedrock surface.

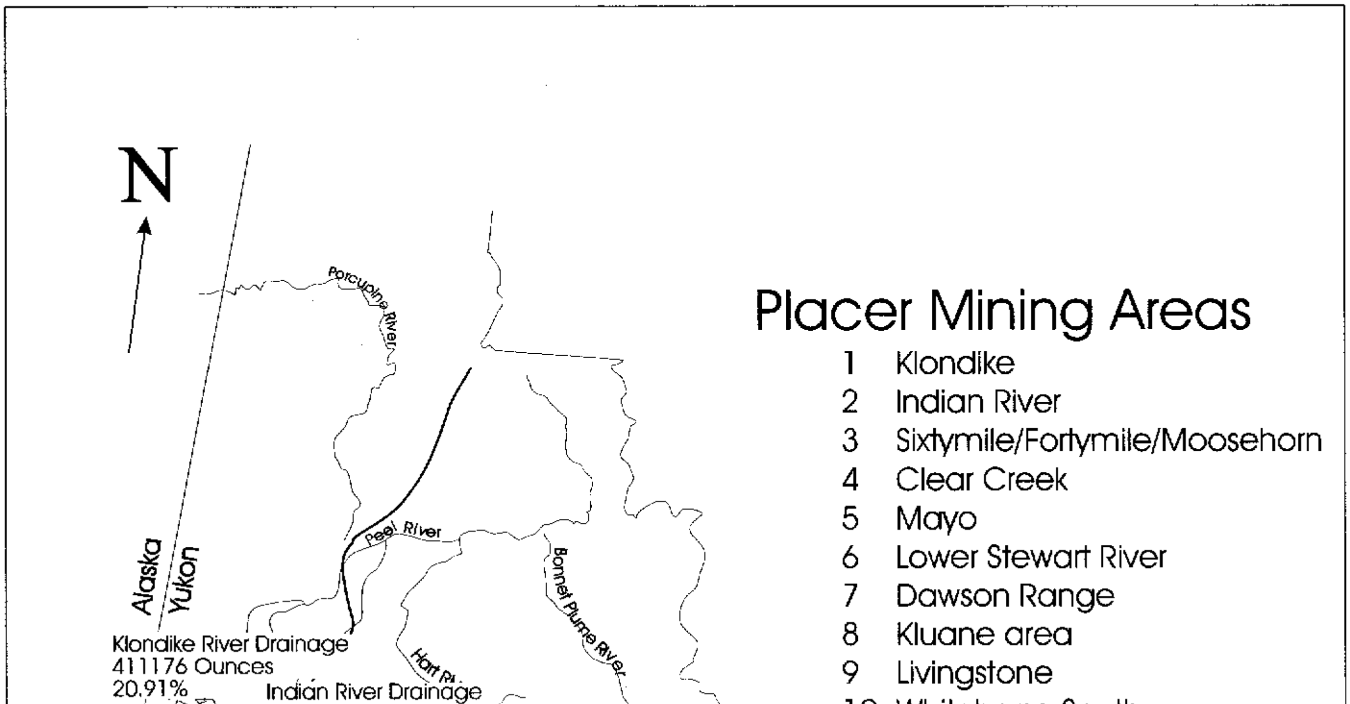

Figure 2. *Yukon Placer Gold Production and Placer Mining Areas, 1978-1996*

Major Categories of Yukon Placer Deposits

Morison (1989) grouped Yukon placer deposits into five broad categories, based on age, geomorphological and sedimentological characteristics. These are:

1) Pliocene to early Pleistocene alluvial placer deposits preserved as high level terraces buried beneath non-auriferous overburden;
2) Pleistocene non-glacial alluvial placer deposits that occur as valley-bottom fill and low to high level terraces in unglaciated terrain;
3) Interglacial placer deposits that occur as valley-bottom alluvial fill or low terraces in drainages that have escaped the effects of glacial erosion;
4) Glacial placer deposits that have formed when gold from regional bedrock or paleoplacer sources was incorporated into glacial drift; and
5) Recent placer deposits that are found as colluvial deposits, valley-bottom alluvial blankets in gulches and tributary valleys, bar deposits in major river systems and beach and nearshore marine deposits.

The characteristics of these categories are shown in Table 1.

Placer deposits in the unglaciated western and northern Yukon fall into categories 1, 2 and 5. Common types of placers in these drainages are valley-bottom alluvial fills, alluvial fans, gulch gravels, high level terraces, and abandoned oxbows and point bars. Placer deposits in the glaciated southern and central Yukon fall into categories 3, 4 and 5. These occur in variably reworked and buried valley-bottom, bench and gulch settings, in glacial till and glaciofluvial gravels, in non-glacial gravels that were deposited on top of glacial drift, and in abandoned oxbows, channels, point- and mid-channel bars.

PLACER MINING INDUSTRY

General

The Yukon placer gold mining industry is a major contributor to the Yukon's economy and has been since the Klondike Gold Rush of

AGE	TERTIARY	QUATERNARY			
	PLIOCENE	PLEISTOCENE			HOLOCENE
ENVIRONMENT AND GEOMORPHIC LOCATION OF PLACERS	Buried alluvial sediments in benches above valley floors	Preglacial or nonglacial buried alluvial sediments in benches above valley floors; valley fill alluvial sediments; alluvial terraces	Interglacial valley fill alluvial sediments; alluvial terraces	Glacial benches of proglacial and ice contact deposits; terminal valley moraines and alpine drift	Valley bottom alluvial plains and terraces; colluvium and slope deposits
GENERAL SEDIMENT CHARACTERISTICS	Mature sediments; well-sorted alluvium with a diverse assemblage of sediment types	Locally derived gravel lithology; moderately to well-sorted alluvium which is crudely to distinctly stratified	Mixed gravel lithology; moderately to well-sorted alluvium, crudely to distinctly stratified	Regionally derived gravel lithology; variable sorting and stratification depending on type of glacial drift	Mixed gravel lithology; moderately to well-sorted alluvium, crudely to distinctly stratified; poorly sorted, massive slope deposits
GOLD DISTRIBUTION	Greater concentration with depth	Discrete concentrations throughout to pay streaks at base of alluvium	Discrete concentrations throughout to pay streaks at base of alluvium	Dispersed throughout; rare pay streaks at base of alluvium and on "false bedrock" layers	Discrete concentrations throughout to pay streaks at base of alluvium; pay streaks follow slope morphology
MINING PROBLEMS	Thick overburden	Thick overburden; variable grade	Variable grade	Low grade and larger volume of material	Variable grade and small volume of auriferous sediment
EXAMPLES	"White Channel Gravel", Klondike area, Yukon	Preglacial fluvial gravels, Clear Creek area; unglaciated terrain, Sixtymile River area	Interglacial gravels in Atlin and Cariboo area, B.C.; Livingstone Creek area, Yukon	Glaciofluvial gravels in Clear Creek area; glacial till in Mt. Nansen area	Valley bottom creek and gulch placers in Clear Creek area

Table 1. *Characteristics of Yukon placer gold deposits (modified from Morison, 1989).*

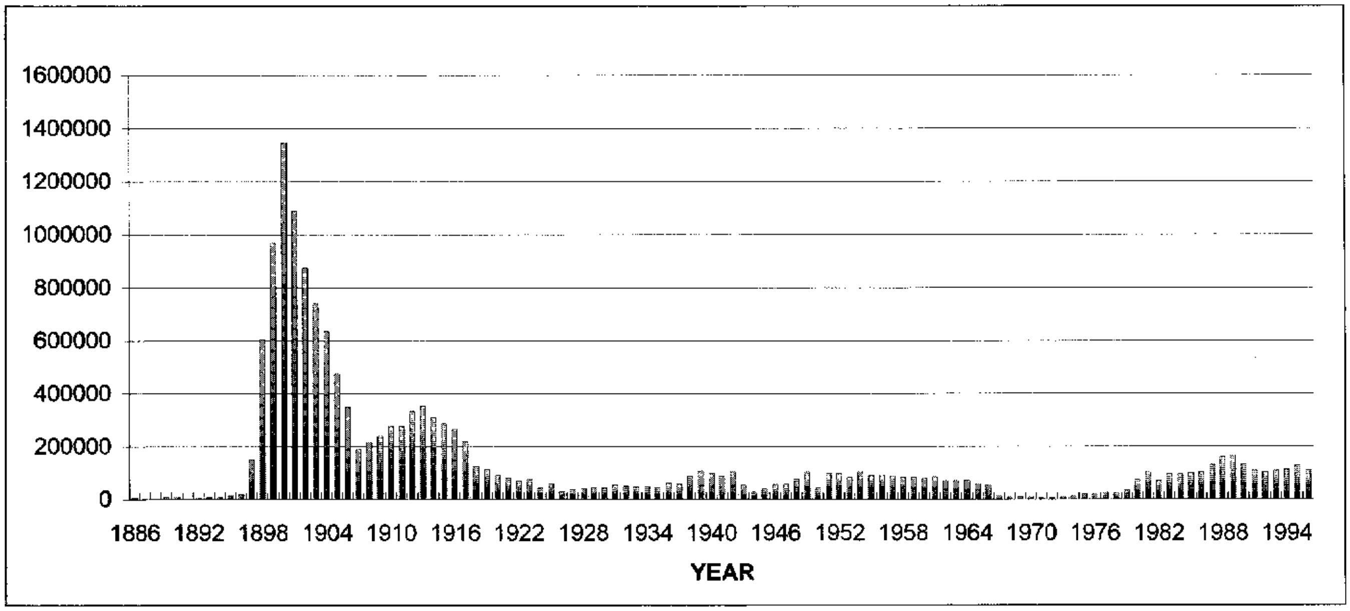

Figure 3. *Yukon Placer Gold production,, 1886 to 1996*

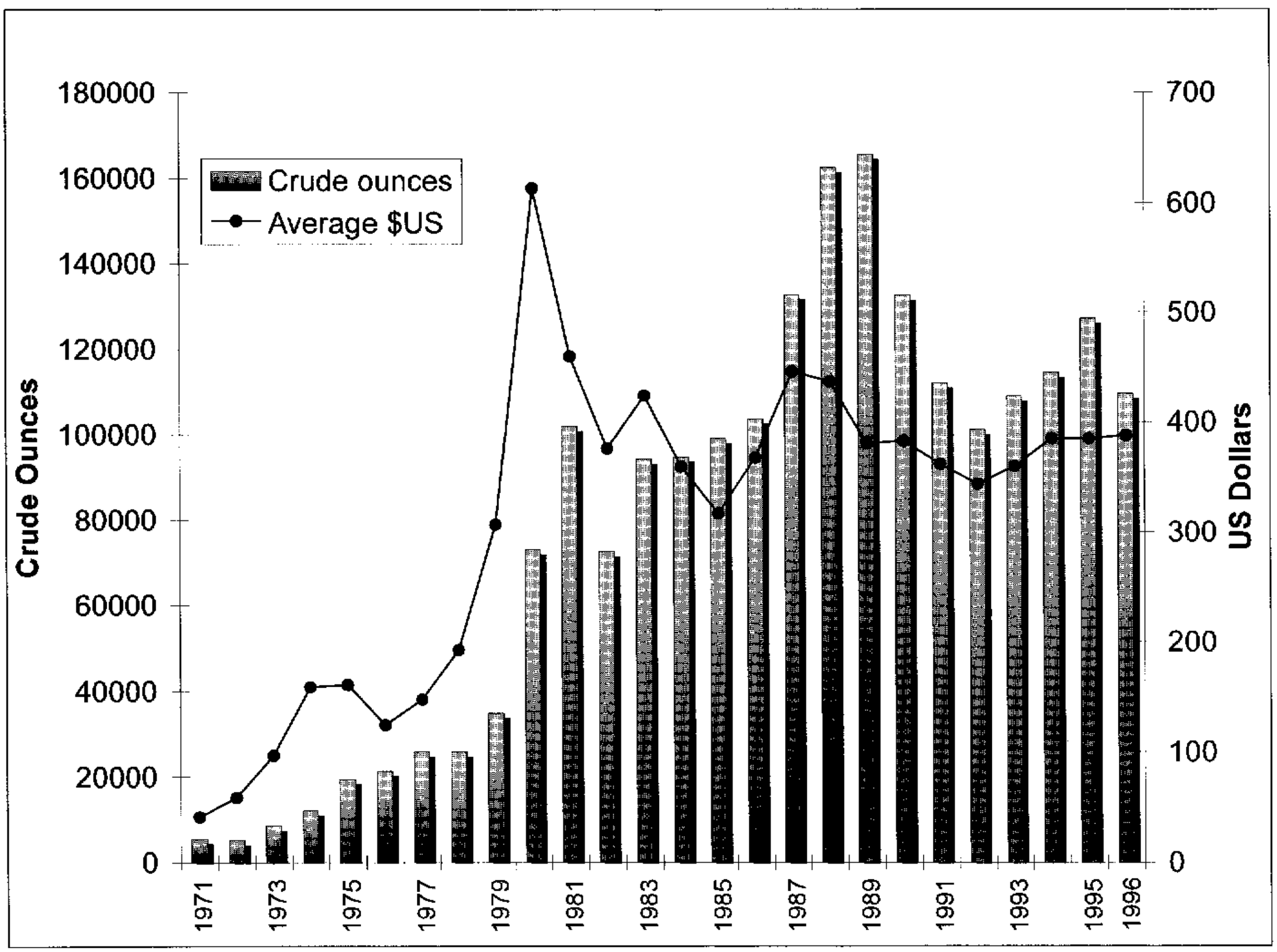

Figure 4. *Yukon Placer Gold Production and Average US Gold Price 1971-1996*

1898. Most operations are family-owned and operated, and direct seasonal employment is estimated to be 700 persons in approximately 170 operations in 1996 (van Kalsbeek, 1997).

Placer Mining Areas

There are ten major placer gold producing areas in Yukon (Fig.2): Indian River, Klondike; West Yukon (Sixtymile/Fortymile/ Moosehorn); Lower Stewart; Clear Creek; Mayo; Dawson Range; Kluane; Livingstone and Whitehorse South. Of these, Klondike and West Yukon are outside the limits of Cordilleran glaciations. The remaining placer mining districts have been variably glaciated over a wide range of ages. The Lower Stewart, Clear Creek and Dawson Range areas lie within the pre-Reid glacial limits, and the Mayo placer area is at the margins of both the Reid and McConnell glacial limits. Kluane, Livingstone and Whitehorse South placer areas lie within the McConnell glacial limit.

Placer Gold Production - General

Since the first recorded gold mining in 1886, over 15 million crude ounces of placer gold have been produced (Fig.3). In 1996, 109,478 crude ounces worth $46 million CDN were mined, a drop of 14% from the previous year's total of 127,143 ounces (van Kalsbeek, 1997).

Since 1987, production has averaged over 126,000 ounces per year, peaking at 165,571 ounces in 1989. Production has not dropped below 100,000 ounces since 1986.

Production has generally followed the fluctuating price of gold, although with a lag of one to two years (Fig. 4). This market-dominated trend may result from increasing or decreasing production on existing claims.

Placer Gold Production by Area

Detailed records of placer gold production by drainage have only been kept since 1978; prior to that only limited general information is available from various Geological Survey of Canada and DIAND reports, and prospector's and miner's accounts.

An examination of recent production records shows that of the 1,966,190 crude ounces mined between 1978 and 1996, 86.14% has come from unglaciated areas and 13.86% was mined from glaciated areas (Fig. 5.). Within the glaciated areas, 5.35% of production is from deposits within the pre-Reid glacial limits, 6.07% is from deposits within the Reid glacial limits and 2.44% is from deposits within the McConnell glacial limits.

Figure 6 summarizes gold production from 1978 to 1996 from the top 25 producing creeks. Many of these creeks have steadily produced, however some have had a large drop in production in the last 5 years, while others have dramatically increased production levels. One of the most notable trends is the amount of placer gold mined from Indian River, which had no recorded gold production prior to 1985. This is an excellent example of an area that previously saw little activity because it was considered below mineable grade. With re-evaluation of its placer gold potential and modern large tonnage mining methods it has become the third highest producing creek over the total 18-year period. Long-time Yukon prospector and miner Pete Risby is credited with first opening up this new placer mining area.

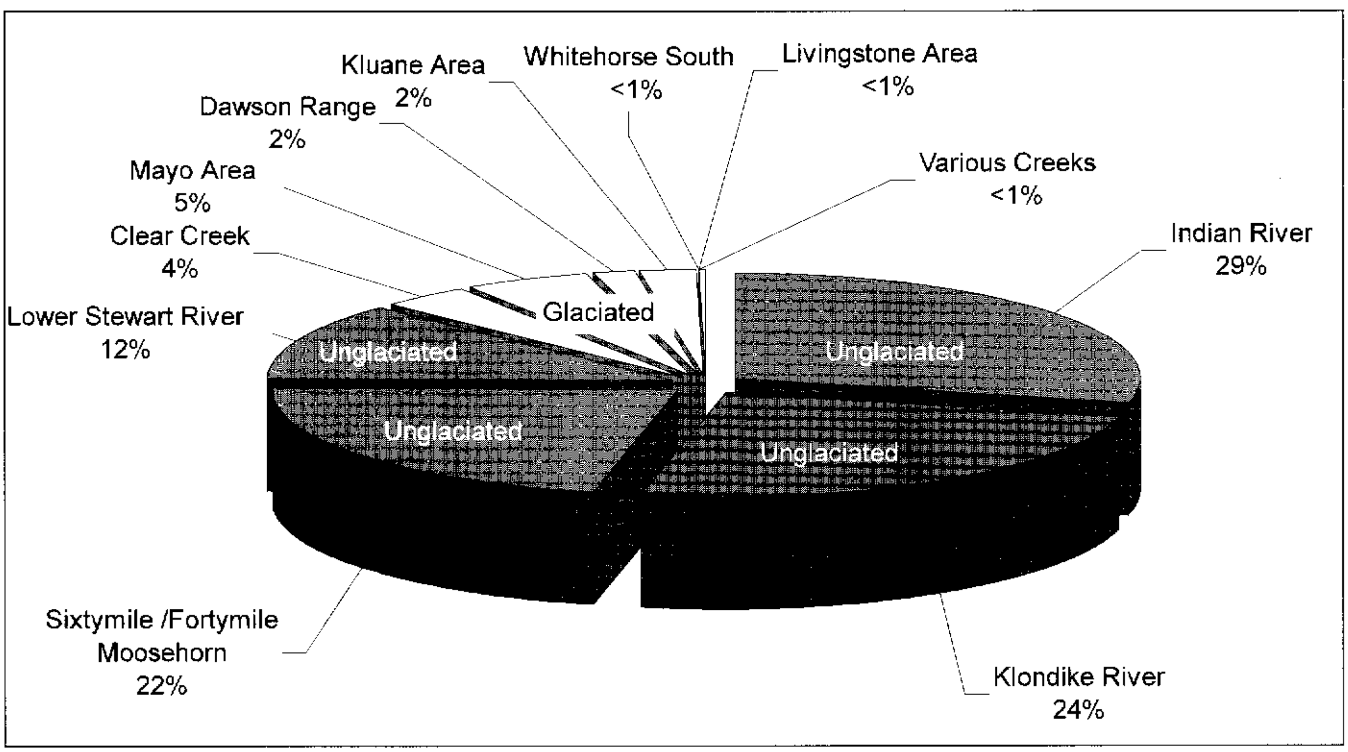

Figure 5. Yukon Placer Gold Production by area, 1978-1996

Placer Exploration

Many areas in the Yukon remain unexplored for new placer gold deposits, both in unglaciated and glaciated areas. Placer exploration targets in unglaciated areas include major drainages such as the Yukon, Stewart and North Ladue rivers. Possible areas of interest include abandoned channels, oxbows and point bars, high level terraces, and tributary gulches and creeks.

The amount of production coming from unglaciated areas has dropped relative to overall Yukon gold production, although it is still by far the highest placer-gold producing area. This is in part due to depletion of reserves in major past-producing drainages like Bonanza and Hunker creeks. Exploration for new placer deposit reserves in Yukon has remained at low levels, while most historic and present mining has taken place in traditional (unglaciated) areas that were discovered at the turn of the century. Consequently, the investigation of non-traditional sites for placer deposits must be increased or gold production will diminish as current sites are depleted.

Based upon our study of non-traditional placer occurrences, new deposits may be found in glacial, glaciofluvial or alluvial settings. Along the margins of previously glaciated areas, undiscovered pre-glacial or interglacial placer deposits may lie buried by glacial and glaciofluvial drift. Lower-grade, higher-tonnage placer deposits may have formed by glaciofluvial reworking of pre-glacial or interglacial placers. Non-glacial placer deposits may also be found unconformably overlying glacial drift. Deeply-incised interglacial valleys oriented obliquely to paleo-ice flow directions are also favorable locations for the preservation of economic placer deposits in glaciated areas.

Interest in exploring for new placer reserves has been sparked lately by new research in the Mayo and Dawson areas by the Yukon Geology Program (Bond, this volume; Hein and LeBarge, this volume) and the Geological Survey of Canada. As this research continues to add to our knowledge of placer gold deposits, exploration activity is expected to continue and new reserves in both unglaciated and glaciated areas may be found.

CONCLUSIONS

Mining and exploitation of Yukon placer deposits has historically focused on unglaciated areas. In recent years, however, some production and exploration interest has shifted to areas that are less accessible and often partly or extensively glaciated. Increasingly sophisticated exploration and mining techniques are used to find placer reserves in areas that previously saw little or no activity. In addition it is clear that the physiography and glacial history of Yukon need to be well understood in the search for new placer deposits, thus ensuring the continuing economic viability of Yukon placer gold mining.

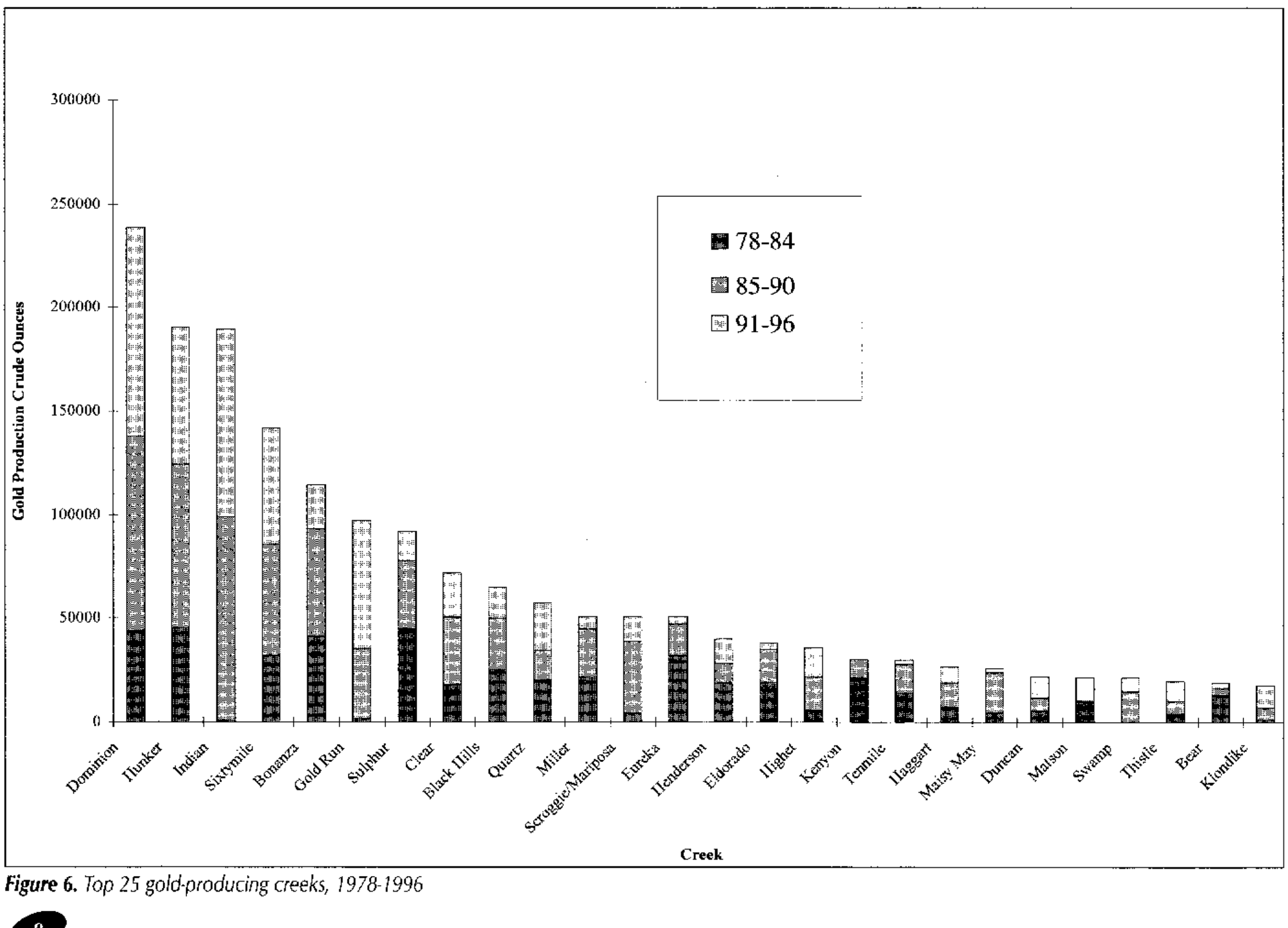

Figure 6. *Top 25 gold-producing creeks, 1978-1996*

ACKNOWLEDGMENTS

This paper benefited from review by F.J. Hein (University of Calgary) and C. Roots (Geological Survey of Canada); gold production statistics were generously provided by Leo van Kalsbeek, Mining Inspection Division, Indian and Northern Affairs Canada, Whitehorse, Yukon.

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Geologic Setting and Stratigraphic Framework of Placer Deposits, Mayo Area, Yukon

Frances J. Hein[1] and William P. LeBarge[2]

HEIN, F. J. AND LEBARGE, W.P. 1997. Geologic Setting and Stratigraphic Framework of Placer Deposits, Mayo Area, Yukon. In: LeBarge, W.P. and Roots, C.F. (editors). 1997. Yukon Quaternary Geology Volume 2, Exploration and Geological Services Division, Northern Affairs Program, Yukon Region, p. 10-29.

ABSTRACT

Placer deposits occur in unusual geological settings in the Mayo Mining District, where gold is mined from Reid-age glacial till and glaciofluvial gravel, and from more recent (McConnell and post-McConnell-age) alluvial fans and fan-deltas. In other districts these types of deposits are not generally explored or prospected for placers. In the Mayo area, placer deposits are best preserved near the maximum limit of glacial ice, where ice-scouring is minimal and depositional processes dominate. Pre-existing alluvial gold deposits were likely buried in this region, where the ice limits of the Reid and McConnell glaciations exist in close proximity. Initial studies of the geomorphology of the region's known placer deposits show that they occur in three main types of landforms of different ages. Alluvial fans and fan-deltas contain placer deposits that are McConnell and younger in age, while valley-bottom placers are likely interglacial, glacial or glaciofluvial deposits of Reid age or older. A number of drainages have not been extensively explored or prospected; however, given similarities with known placer occurrences in the area, the potential for discovery of new placer deposits is good for many sites in the Mayo map area.

RÉSUMÉ

Les gîtes placériens du district minier de Mayo se présentent dans des contextes géologiques atypiques. Ils sont exploités dans des tills et des graviers fluvioglaciaires d'âge Reid et dans des cônes alluviaux et des cônes-deltas plus récents (d'âge McConnell et post-McConnell). Dans les autres districts, on n'explore et on ne prospecte généralement pas de tels terrains à la recherche de placers. Dans la région de Mayo, les dépôts placériens sont mieux conservés à proximité de l'extension maximale des glaces, où l'affouillement par celles-ci est peu poussé et où dominent les processus sédimentaires. Les dépôts aurifères alluviaux formés antérieurement ont vraisemblablement été enfouis dans cette région, là où les limites d'extension des glaciations de Reid et de McConnell sont très voisines. Les études initiales de la géomorphologie des gîtes placériens connus de la région démontrent qu'ils se présentent dans trois types principaux de formes de terrain d'âge différent. Les cônes alluviaux et les cônes-deltas renferment des gîtes placériens d'âge McConnell et plus récent, alors que les placers de fond de vallée sont vraisemblablement des dépôts interglaciaires, glaciaires ou fluvioglaciaires d'âge Reid ou plus ancien. Certains bassins versants n'ont pas été explorés ou prospectés systématiquement; toutefois, en raison des similitudes avec les occurrences connues de placers dans la région, le potentiel de découverte de nouveaux gîtes placériens dans plusieurs sites de la région cartographique de Mayo est élevé.

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INTRODUCTION

In 1895 placer gold was discovered on Haggart Creek, just below Dublin Gulch, followed in 1898 by other placer gold discoveries in Dublin Gulch and in the Klondike. In 1904 scheelite was discovered with the placer gold in Dublin Gulch, followed by the discovery of lode gold there in 1907 (Mayo Historical Society, 1990). The first silver vein was discovered in 1906 on Galena Creek, and in 1913 production began on the Silver King Vein. In 1919 a staking rush was precipitated by the discovery of silver veins on Keno Hill. Since that time, the Mayo area has seen a large number of silver/galena and lode-gold mines, as well as an active placer gold mining industry. At Dublin Gulch and Haggart Creek tungsten as scheelite occurs in both lode and placer deposits along with native gold. Other associated minerals in eluvial and alluvial gold placers of the area include native silver, hematite, magnetite, arsenopyrite, pyrite, sphalerite, galena and ruby silver (pyrargyrite). Because many lode sources are well-known with a mineral zoning pattern (Franzen, 1986; Lynch, 1986; Watson, 1986) and documented placers have interesting suites of associated heavy minerals, this area is a unique district in which to examine the sedimentology of placer deposits. Furthermore, the area appears to be at the limit of glacial ice advances and affords an opportunity to examine the distribution of gold placers within glacially influenced landforms and glacial sediments. This study complements another study in the Mount Nansen area of central Yukon, in which significant amounts of placer gold are associated with a glacial diamicton at the diamicton/bedrock contact (LeBarge, 1995).

In May 1996 the Yukon Geology Program began a two-year placer research project to identify new placer potential in the Mayo

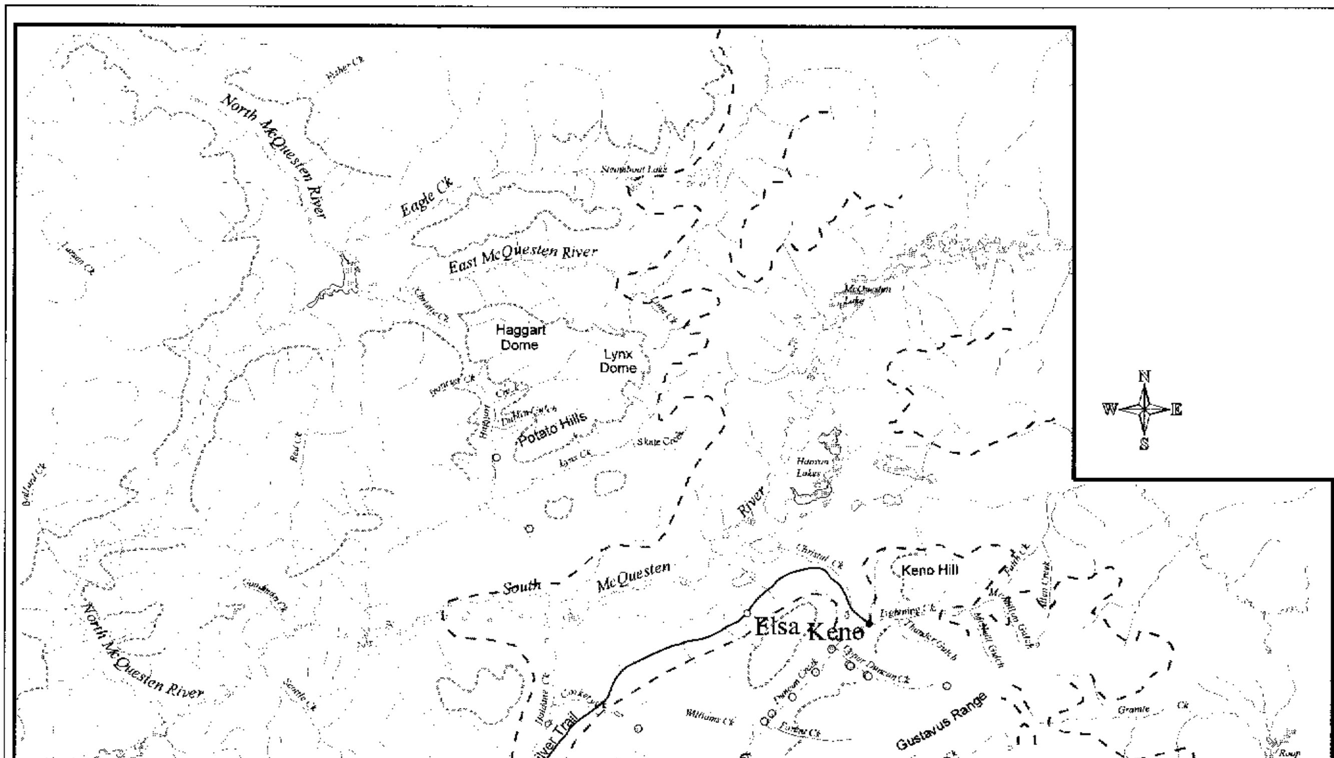

Figure 1. *Section location map, Mayo area, central Yukon, showing the location of the measured detailed stratigraphic sections, major drainages, and the limits of the Reid and McConnell glaciations.*

Table 1. *Location of stratigraphic and lithologic sections measured in the Mayo area, central Yukon*

Section	Property	NTS	Latitude	Longitude	Elev. ft	Geol	Creek	Tributary To	Landform	Glacial Limit
DC1-95		105M14	63 52.52	135 21.93	3140	WPL	Duncan	Mayo River	Alluvial Bench	McConnell
DC2-95		105M14	63 52.78	135 22.63	2920	WPL	Duncan	Mayo River	Alluvial Bench	McConnell
DK1-95	D. Klippert	106D4	63 49.38	136 04.13	2550	WPL	Seattle	S. McQuesten River	Fluvial Valley	Reid (?)
FE1-95	F. Erl	115P09	63 45.92	136 12.82	3450	WPL	Highet	Minto Creek	Fluvial Valley	Reid (?)
FH9601		105M14	63 52.21	135 11.48	4150	FJH	Upper Duncan	Duncan Creek	Fluvial Valley	Post-Reid
FH9602	H. Barchen	105M14	63 52.64	135 18.45	3240	FJH	Upper Duncan	Duncan Creek	Fluvial Valley	Reid
FH9603	J. Brinkerhoff	105M14	63 52.52	135 20.60	2770	FJH	Upper Duncan	Duncan Creek	Alluvial Bench	McConnell
FH9604		105M14	63 48.30	135 29.52	2450	FJH	Duncan	Mayo River	Alluvial Bench	Reid
FH9605		105M14	63 53.64	135 21.30	2880	FJH	Duncan	Mayo River	Alluvial Bench	McConnell
FH9606		105M14	63 49.27	135 28.91	2490	FJH	Duncan	Mayo River	Alluvial Bench	McConnell
FH9607		105M14	63 49.18	135 28.98	2480	FJH	Duncan	Mayo River	Alluvial Bench	McConnell
FH9608		105M14	63 50.36	135 38.00	2550	FJH	Duncan	Mayo River	Alluvial Bench	Reid
FH9609		105M14	63 50.68	135 27.16	2600	FJH	Duncan	Mayo River	Alluvial Bench	Reid
FH9610		105M14	63 51.13	135 26.31	2640	FJH	Duncan	Mayo River	Alluvial Bench	Reid
FH9611		105M14	63 51.68	135 25.07	2660	FJH	Duncan	Mayo River	Alluvial Bench	Reid
FH9612		105M14	63 52.74	135 22.65	2740	FJH	Duncan	Mayo River	Paleo-Alluvial Fan	Reid
FH9613		105N13	63 58.29	133 47.83	2050	FJH	Stewart River	Yukon River	Fluvial Valley	McConnell
FH9614	H. Barchen	105M14	63 53.07	135 19.91	3030	FJH	Upper Duncan	Duncan Creek	Fluvial Valley	Reid
FH9615		115P09	63 44.20	136 05.20	2580	FJH	Highet	Minto Creek	Fluvial Valley	McConnell
FH9616	Lucien LeRoy	105M14	63 55.20	135 12.00	3700	FJH	Hope Gulch	Lightning Creek	Gulch Mouth	Reid
FH9617		105M14	63 56.60	135 22.19	2770	FJH	Galena Hill	Christal Creek	Cut on Hillside	McConnell
FH9618	H. Barchen	105M14	63 53.97	135 15.07	3790	FJH	Unnamed Trib.	Thunder Gulch	Gulch Valley	Reid
FH9619 (1)	H. Barchen	105M14	63 54.00	135 14.77	3710	FJH	Thunder Gulch	Lightning Creek	Gulch Valley	Reid
FH9619 (2)	H. Barchen	105M14	63 54.08	135 14.92	3750	LCW	Thunder Gulch	Lightning Creek	Gulch Valley	Reid
FH9620	F. Taylor	105M14	63 48.903	135 28.808	2500	FJH	Duncan	Mayo River	Fluvial Valley	McConnell
FH9621		105M14	63 44.85	135 25.65	2680	LITH	Davidson	Mayo River	Canyon Cut	Reid/Post-Reid
FH9622	P. Rivest	105M14	63 44.00	135 25.50	2600	LITH	Davidson	Mayo River	Canyon Cut	McConnell
FH9623	D. Szabo	105M5	63 27.20	135 35.30	2470	LITH	Empire	Francis Creek	Alluvial Valley	McConnell ?
FT1-95	F. Taylor	105M14	63 48.57	135 29.20	2420	WPL	Duncan	Mayo River	Fluvial Valley	McConnell
FT2-95	F. Taylor	105M14	63 48.63	135 29.07	2420	WPL	Duncan	Mayo River	Fluvial Valley	McConnell
FT3-95	F. Taylor	105M14	63 48.72	135 29.05	2420	WPL	Duncan	Mayo River	Fluvial Valley	McConnell
FT4-95	F. Taylor	105M14	63 48.78	135 29.00	2420	WPL	Duncan	Mayo River	Fluvial Valley	McConnell
FT5-95	F. Taylor	105M14	63 48.88	135 28.90	2380	WPL	Duncan	Mayo River	Fluvial Valley	McConnell

FT6-95	F. Taylor	105M14	63 48.88	135 28.87	2460	WPL	Duncan	Mayo River	Fluvial Valley	McConnell
FT7-95	F. Taylor	105M14	63 47.32	135 30.35	2480	WPL	Duncan	Mayo River	Fluvial Valley	McConnell
FT8-95	F. Taylor	105M14	63 47.53	135 30.05	2320	WPL	Duncan	Mayo River	Fluvial Valley	McConnell
General	H. Barchen	105M14	63 52.64	135 18.45	3300	FJH	Upper Duncan	Duncan Creek	Fluvial Valley	Post-Reid
General	H. Barchen	105M14	63 52.65	135 18.46	3180	FJH	Upper Duncan	Duncan Creek	Fluvial Valley	Reid
General	H. Barchen	105M14	63 52.63	135 18.36	3225	FJH	Upper Duncan	Duncan Creek	Fluvial Valley	Reid
General	H. Barchen	105M14	63 52.64	135 18.44	3250	FJH	Upper Duncan	Duncan Creek	Fluvial Valley	Reid
Gill Gulch	T. Takacs	106D4	64 01.04	135 51.18	2530	FJH	Gill Gulch	Haggart Creek	Alluvial Fan Mouth	Reid
HB1-95	H. Barchen	105M14	63 53.05	135 19.50	3350	WPL	Upper Duncan	Duncan Creek	Fluvial Valley	Reid
HB2-95	H. Barchen	105M14	63 52.63	135 18.43	3220	WPL	Upper Duncan	Duncan Creek	Fluvial Valley	McConnell
HB3-95	H. Barchen	105M14	63 52.63	135 52.63	3320	WPL	Upper Duncan	Duncan Creek	Fluvial Valley	Reid (?)
HB4-95	H. Barchen	105M14	63 53.47	135 20.57	2940	WPL	Upper Duncan	Duncan Creek	Fluvial Valley	McConnell (?)
HT1-95		115P09	63 45.85	136 10.72	2980	WPL	Highet	Minto Creek	Fluvial Valley	Reid (?)
HT2-95		115P09	63 43.93	136 07.82	2500	WPL	Highet	Minto Creek	Fluvial Valley	Reid (?)
HT3-95		115P09	63 43.88	136 07.77	2500	WPL	Highet	Minto Creek	Fluvial Valley	Reid (?)
KK1-95	K. Klippert	106D4	63 45.92	136 11.52	3125	WPL	Highet	Minto Creek	Alluvial Bench	Reid (?)
KK2-95	K. Klippert	106D4	63 55.60	136 11.55	2375	WPL	Goodman	S. McQuesten River	Fluvial Valley	Reid (?)
Ledge Ck	R. Barchen	105M10	63 41.50	134 51.50	2500	FJH	Ledge	Mayo Lake S. Arm	Alluvial Fan Apex	McConnell
LW9601	H. Barchen	105M14	63 52.61	135 18.36	3235	LCW	Upper Duncan	Duncan Creek	Alluvial Terrace	Reid
LW9602	H. Barchen	105M14	63 52.64	135 18.45	3160	LCW	Upper Duncan	Duncan Creek	Fluvial Valley	Reid
LW9603	H. Barchen	105M14	63 53.08	135 19.88	3170	LCW	Upper Duncan	Duncan Creek	Fluvial Valley	Reid
LW9604	H. Barchen	105M14	63 53.05	135 19.83	3120	LCW	Upper Duncan	Duncan Creek	Fluvial Valley Wall	Post-Reid
LW9605	FH9601	105M14	63 52.21	135 11.48	4150	LCW	Upper Duncan	Duncan Creek	Fluvial Valley	Post-Reid
LW9606		105M14	63 47.64	135 14.35	2450	LCW	Dirksen	Mayo Lake N. Arm	Fan Delta	McConnell
LW9607	FT8-95	105M14	63 47.53	135 30.05	2320	LCW	Duncan	Mayo River	Alluvial Terrace	McConnell
LW9608	Ted Takacs	106D4	64 01.809	135 51.488	2530	LCW	Gill Gulch	Haggart Creek	Alluvial Fan Mouth	Reid
LW9608A	Mel Zeiler	105M14	63 50.51	135 27.47	2550	FJH	Duncan	Mayo River	Alluvial Terrace	Reid
LW9609	Ted Takacs	106D4	64 01.56	135 51.341	2530	LCW	Gill Gulch	Haggart Creek	Fluvial Valley	Reid
LW9609A		106D4	64 01.486	135 51.340	2530	LCW	Haggart	S. McQuesten River	Fluvial Valley	Reid
MP1-95	M. Powers	115P09	63 44.27	136 08.58	2560	WPL	Highet	Minto Creek	Fluvial Valley	Reid (?)
MW1-95	M. Wozniak	105M10	63 43.67	135 01.57	2400	WPL	Anderson	Mayo Lake S. Arm	Canyon Cut	McConnell
RB1-95	R. Barchen	105M10	63 40.62	134 50.67	2450	WPL	Ledge	Mayo Lake S. Arm	Alluvial Fan Apex	McConnell
RH1-95	R. Holway	106D4	64 01.03	135 51.18	2500	WPL	Haggart	S. McQuesten River	Fluvial Valley	Reid
RH2-95	R. Holway	106D4	64 00.90	135 51.07	2530	WPL	Haggart	S. McQuesten River	Fluvial Valley	Reid
UD9601	H. Barchen	105M14	63 52.61	135 18.36	3235	WPL	Upper Duncan	Duncan Creek	Fluvial Valley	Reid
WL9603	F. Taylor	105M14	63 48.88	135 28.87	2460	WPL	Duncan	Mayo River	Alluvial Valley	Post-Reid
WL961 & 2	M. Powers	115P09	63 44.40	136 08.50	2565	WPL	Highet	Minto Creek	Alluvial Valley	Reid/Post-Reid

Mining District. This program was largely done as a research contribution agreement between the University of Calgary, Department of Geology and Geophysics, and the Yukon Geoscience Program, Yukon Territorial Government, and with logistical and staff support funded by Indian and Northern Affairs Canada, Exploration and Geological Services Division. In May 1997 the second field season commenced with emphasis on the sedimentology and stratigraphic setting of the western part of the Mayo Mining District, and will include detailed stratigraphic and sedimentological work in the Dublin Gulch, Highet Creek, and Duncan Creek areas (Fig. 1), as well as further mapping and geochemical studies along the northern and northwestern extent of the Mayo Mining District. The results reported here are considered

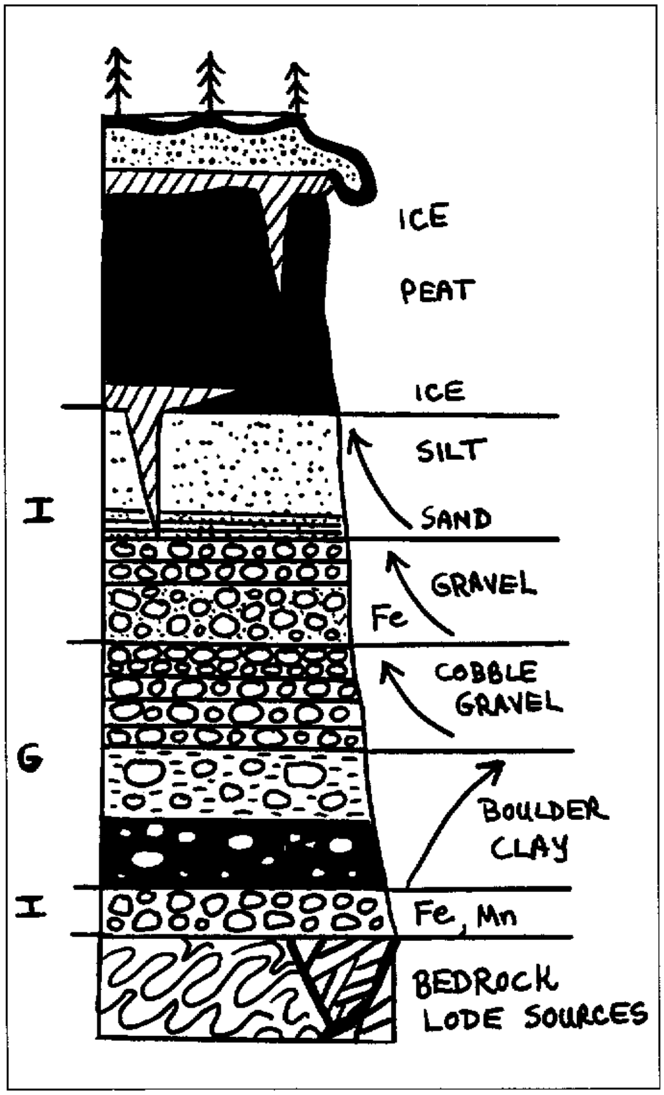

Figure 2. Representative composite stratigraphic succession, up to 20 m thick, showing an interglacial-glacial-interglacial (IGI) cycle of sedimentation sandwiched unconformably between lode-gold bearing bedrock and post-McConnell permafrost, peat and soil horizons. Based upon sections measured on Upper Duncan Creek, central Yukon. Arrows pointing to the upper left indicate grain size decreasing upward; to upper right: increasing upward.

preliminary but provide a working framework for the continuation of the project and ongoing studies. These results will be revised following the second (final) field season.

Surficial geomorphic mapping along with detailed stratigraphic section descriptions of mine-cut, road, or stream-cut sections are the main field data. In 1995 reconnaissance studies centred on the Duncan Creek and Mayo Lake areas, with some preliminary work in the Gill Gulch, Highet, Haggart, Goodman and Seattle Creek drainages (Table 1). During the 1996 field season, Reid and McConnell limits were mapped mainly for the eastern and central parts of the study area (Fig. 1). Within this part of the study area, forty-two sites were visited for sedimentological and stratigraphic description, of which twenty were of sufficient exposure for detailed stratigraphic analysis (Fig. 1, Table 1). Some of these, in areas of active placer mining, were revisited during the field season to document sequential changes in sediment types and facies as active mining cut back into the hillsides. These mining operations gave excellent exposure of vertical and lateral facies trends, and afforded the opportunity to ascertain the stratigraphic relationships between different units. Additional natural exposures and gravel pits along stream- and road- courses were measured for stratigraphic and sedimentological control. Sections were described with emphasis on physical sedimentary features, including: grain size, bed thickness, gravel fabric, primary sedimentary structures, lithology of clasts, rounding of clasts, and cryogenic features such as ice-wedge casts, ice-loading contacts and disruption of primary features; colluviation and down-slope wasting; and pedogenesis. Samples were collected for geochemistry, assay, mineralogical, heavy mineral and grain-size analysis. Initial heavy mineral results are included in Appendix A. In fine-grained interbedded organic horizons, samples were taken for radiocarbon dating and palynological analysis. The preliminary mapping results are presented in Bond (this volume).

PREVIOUS WORK

A review of the previous work on placers and surficial deposits of the Mayo Mining District is presented in LeBarge (1996a, 1996b), with the highlights summarized here. Surficial geology and/or placer-related studies in central Yukon include: Bostock's (1948, 1966, 1969) compilations of glacial limits, Hughes' detailed mapping of the McConnell glacial limits (Hughes, 1982; 1987; Hughes et al., 1969, 1972), Quaternary geology studies by Giles (1993) of sections near the Mayo town site and Mayo Indian Village, Pleistocene mammal studies of Dublin Gulch and the Mayo placer mining areas by Harington (pers. comm.), soil surveys of selected areas near Mayo (Mougeot, 1993), and permafrost studies in the Mayo and Duncan Creek areas (Burn, 1990, 1994; Burn and Friele, 1989; Wilson et al., 1996). Mougeot and others have produced a series of open file geological processes inventory maps for Mayo and the surrounding area (Mougeot and Walton, 1996a, 1996b, 1996c; Doherty et al., 1994). Earlier geochemical work on gold by Boyle and others focused in the Keno Hill area (Kindle, 1955; Boyle and Gleeson, 1972; Boyle, 1979). Bedrock gold-silver occurrences were compiled for the Yukon by Morin (1989), with a more detailed compilation of bedrock and placer gold/silver occurrences in the Mayo area by Kreft (1993) and for nearby areas by Carlyle (1995a, 1995b). This work has been incorporated into the Placer Minfile by Hein et al. (1996). Regional geochemical reconnaissance stream sediment and water geochemical data for Mayo map area (105 M) were collected and collated by the Geological Survey of Canada (Friske and Hornbrook, 1989) and, where appropriate, these data are being incorporated into the present stream- and sediment sampling program. Regional overviews of placer geology in Yukon are given by Morison (1989), McLeod and Morison (1996), with summaries of central Yukon by LeBarge (1996a, this volume).

Bedrock mapping in the Mayo area includes Poole (1965), Green (1971, 1972), Hunt et al. (1996), Murphy and Roots (1996), Roots (1991, 1997), and Roots and Murphy (1992a, 1992b). Mineral zoning within bedrock in the Keno Hill area was studied by Lynch (1986, 1989). An investigation into reprocessing of tailings at Elsa was done by Hawthorne (1996).

Other studies of interest include: the origin and permafrost characteristics of the "muck" in the Klondike (Fraser, 1995; Fraser and Burn, in press; Kotler, in prep.); Harris' (1994) chronostratigraphic studies of glaciations and permafrost in the Cordillera; mapping of glacial limits and surficial deposits in the Dawson area and Mackenzie Mountains (Duk-Rodkin, 1996; Duk-Rodkin and Hughes, 1991; Duk-Rodkin et al., 1996); glacial limit mapping and study of potential placer creeks north of Mayo (Bond, this volume); paleosol development in central Yukon (Rutter et al., 1978; Smith et al., 1986; Tarnocai et al., 1985; Tarnocai and Schweger, 1991); sedimentological studies on the Klondike Terrace placer gravels near Dawson (Froese, in prep.; Froese and Hein, 1996); Quaternary and surficial geology of the McQuesten map area (Bond, 1996, 1997); and plant and insect fossil studies from the Mayo Indian Village section (Matthews et al., 1990).

Stratigraphic Framework and Geologic Setting

A wide variety of geomorphic settings host placer deposits in the Mayo Mining District, including: alluvial fans, fan-deltas, gulch gravels, valley-bottom alluvial plains, bedrock terrace or bench gravels, glaciolacustrine basin fills, glaciofluvial outwash plains, and glacial-ice contact features, including kame-terraces, morainal ridges, subglacial outwash channels (eskers), and grounded- or stagnation-ice that formed diamict (boulder-clays or sandy-silty-boulder clay), interpreted as till. Other diamict originated during periods of reworking of the primary glacial deposits, and these include debris flow, colluvial-slope, and permafrost deposits. The distinction of glacial-ice diamict from other diamict that originated during periods of reworking is not easy (cf. Morison and Hein, 1986; Hein et al., 1990; Syvitski and Hein, 1991; Hein and Syvitski, 1992), and this is the subject of ongoing studies as part of the present research programme (MacKinnon and Hein, in prep.).

The placer gravels overlie bedrock including Hyland Group metasandstone, conglomerate, siltstone, shale and phyllite; Road River Group siltstone and chert; and Earn Group coarse chert-pebble conglomerate, sandstone, siltstone, with minor dark grey to black limestone and chert (Table 2). These metasedimentary rocks occur in broad open folds and widely spaced thrust faults offset by narrow, northwesterly-trending faults. In the central and northern part of the study area, thick dark grey (Keno Hill) quartzite is locally intensely fractured, folded, and foliated with prominent quartz-veining, local diabase and metadiorite dykes, sills and other intrusions. The Robert Service Thrust Fault, which traverses the area from Mt. Haldane to Tiny Island Lake, has associated fold-and-fault intersections, overturning, and local quartz veining. A northwesterly-trending band of granitic and quartz monzonite intrusions cross the map-sheet from the Roop Lakes to the Potato Hills near Dublin Gulch, and Scheelite Dome near Highet Creek. Other major intrusions or dyke systems occur to the south in the Talbot Plateau area, and northwest of the map-sheet towards the Clear Creek drainage. Although lode sources of gold for the placers have not been conclusively identified, it is likely that some of the placer gold and silver may be derived from vein deposits associated with these intrusions.

Three major episodes of glaciation in the Quaternary have affected the geomorphology and sedimentary record of central Yukon. These are: the pre-Reid, the Reid, and the McConnell, in order from oldest to youngest (Table 2). These periods of glaciation, along with the associated interglacial intervals, have left a significant mark on the preserved stratigraphy as well as accounting for complex drainage and topography of the Mayo District's placer deposits. A unique characteristic of the Mayo area is its location at the limit of both the McConnell and Reid glaciations. Sedimentological and geomorphic influences that affected the area include: 1) weathering, removal and sorting of bedrock and preglacial surficial deposits; 2) erosion, sculpting and deposition of glacial landforms; 3) fluvial, mass-flow, and ice-reworking of surficial deposits during interglacial and glacial times; and, 4) flooding and ponding of local drainages associated with morainal/ice-damming and ice-meltout flows.

Bedrock sources of gold include quartz veins spatially related to intrusions in the area. In the Keno Hill Silver District (United Keno Hill Mines) placer silver nuggets have been recovered a few kilometres downstream from silver-bearing quartz veins during historic and present placer mining. Other secondary sources of placer gold and silver include older valley-bottom and bedrock terrace paleoplacers, and eluvial gold and silver in areas of marked colluviation and regolith development overlying quartz-veined bedrock. Well-worn and rounded silver nuggets along with galena in the Duncan Creek drainage suggest that eroded silver- and galena-bearing quartz veins on Keno Hill may have been the local source. In Thunder Gulch the placer gold is more angular and less travelled, perhaps originating from local bedrock veins within the headwaters on the west flank of Mount Hinton (Yukon Minfile occurrence 105M/52). To the east, Granite and Keystone creeks also host placer gold that may have been derived from Mount Hinton. Other local gold sources include quartz-veins within phyllite, grit and phyllitic schist of the Hyland Group bedrock; local stocks, veins, intrusions or hydrothermal systems associated with plutons at Roop Lakes, Scheelite Dome and the Potato Hills. (Roots and Murphy, 1996, pers. comm; and cf. references). Of possible significance is the location of the Robert Service Thrust Fault intersection with folds in the area of high gold values in the Duncan Creek and Upper Duncan Creek drainages (cf. Roots and Murphy, 1992b; Murphy and Roots, 1996).

GLACIAL LIMITS AND STRATIGRAPHY OF PLACER DEPOSITS

The entire Mayo area was inundated by the earliest pre-Reid glaciation, although it is impossible to map the pre-Reid limit because the older glacial deposits were overridden and reworked by subsequent glaciations. The Mayo area is near the limit of both the Reid and McConnell glaciations, and some western areas remained unaffected by these younger glaciations, namely, those beyond the Reid limit (Fig. 1). In some areas the McConnell and Reid limits are very close to one another, within a kilometre or so. This is particularly true for the following areas: Steamboat Lake and Steamboat River; headwaters of the North McQuesten River; upper tributaries of Lynx Creek; north of Halfway Lakes; north and east flanks of Galena Hill, just southeast of Elsa; south of Gambler Lake; and in the vicinity of Ping Pong Creek and Empire Creek. In these areas, the McConnell Limit is distinguished by very fresh moraines and other ice-contact features; whereas the ice-contact features associated with the Reid Limit are much more subdued and weathered. In areas where it is impossible to distinguish whether the surficial deposits are McConnell or Reid, the limit was not mapped (Fig. 1).

The overall Quaternary stratigraphy of the area comprises, from oldest to youngest: glacial deposits of pre-Reid; Reid; and McConnell glaciations and intervening interglacials; and Recent deposits (Table 2). Associated with each of these time-periods are a variety of geomorphic settings. During glacial and periglacial times these include: ice-contact moraines, eskers, cirques, tarns, drowned river valleys associated with glacial lakes, glaciofluvial outwash plains and deltas. During interglacials and Recent (post-McConnell) time the geomorphic settings are gulch and tributary valley fills, channel fills, terraces, trunk valleys, colluvial slopes, alluvial fans, fan-deltas and lakes. In sites of the Mayo map area at or very near to the limit(s) of the McConnell and Reid glaciations, many of the glacial landforms and features are not erosional , but rather depositional in origin. With the exception of the major trunk valleys that carried the glacial ice, smaller tributary valleys were covered with a thin veneer or a thick blanket of glacial and/or glaciofluvial/lacustrine debris that protected the underlying sediment from further erosion. In some areas these protected areas are underlain by paleoplacer deposits.

Glacial or glaciofluvial/lacustrine deposits alternate with interglacial alluvial sediments throughout the sedimentary record. Depending upon the geomorphic setting in which the glacial or interglacial sediments were emplaced at the time of deposition, the internal sedimentary structures and lateral facies can vary. For example, interglacial fluvial valley or gulch gravels differ in terms of sedimentary features from interglacial alluvial-fan or fan-delta deposits. In addition, depending upon local landforms and the history of erosion, deposition and reworking, the preserved stratigraphy varies from place to place. In areas of active McConnell glacial erosion and downcutting, for example along the margins of Mayo Lake, very little of the pre-McConnell sediment package is preserved, and the deposits may are all likely McConnell age or younger. By contrast, areas at or near the glacial limit are protected from glacial ice-erosion and dominated by depositional processes. In this instance a thick stratigraphic record may be preserved, consisting of the sediments of two or three glacial ice advances and the alternating thinner interglacial alluvium. In high mountainous or hillslope areas above the Reid glacial limit, a very thin (condensed) section may be preserved. These consist of thin regoliths, coarse-grained mass-flow deposits, or felsenmeer on bedrock, and may be any age from pre-Pliocene to Recent unless datable fine-grained paleosols or other organic materials are found.

An ideal or type section for the Mayo area surficial deposits is problematic because of the complex history of erosion and deposition. It is possible to present the basic components of an ideal cycle of sedimentation (interglacial to glacial to interglacial), if the main components of this history are preserved in the stratigraphic record. This is shown schematically in Figure 2, based upon the Quaternary record in Upper Duncan Creek. All surficial deposits overlie bedrock with a major unconformity. The first unit is commonly a thin mantle of regolith or interglacial alluvial gravel that often shows Fe-Mn staining. This regolith or gravel may be very coarse grained and poorly sorted, if not reworked significantly prior to emplacement of the overlying glacial package. If significant water washing of the regolith or basal gravel into gulches, alluvial fans and main valley systems occurred, the gravel shows better sorting, is more rounded, and has stratification. Locally (in protected areas) thin overbank fines and rare paleosols are preserved, but in general this basal gravel/regolith is poorly constrained. If this basal gravel or regolith overlies bedrock lode-gold sources, these sediments would host eluvial or placer gold.

The glacial sediment is usually characterized by a coarse-grained boulder clay. This boulder-clay may consist of widely dispersed cobbles or boulders within blue-grey clay that coarsens upsection into a more massive silty-sandy-boulder-clay (diamict). Glacial sediment is very poorly sorted and generally lacks stratification, although locally may be vaguely-stratified. Clasts are very angular, angular or rounded, with occasional ventifacts. In some localities (Thunder Gulch, Upper Duncan and Duncan creeks), resedimented wood debris may be dispersed within the lowermost layers of the boulder-clay. If the glaciofluvial succession was deposited and preserved above the diamict, the gravels become finer grained, more rounded, better sorted and well-stratified, with some crossbedding preserved. The overall glacial - glaciofluvial boulder-gravel succession would be coarsening-, then fining-upwards. Interglacial gravels are generally Fe- and/or Mn-stained, and form lenticular packages of channel-fills within main valleys or

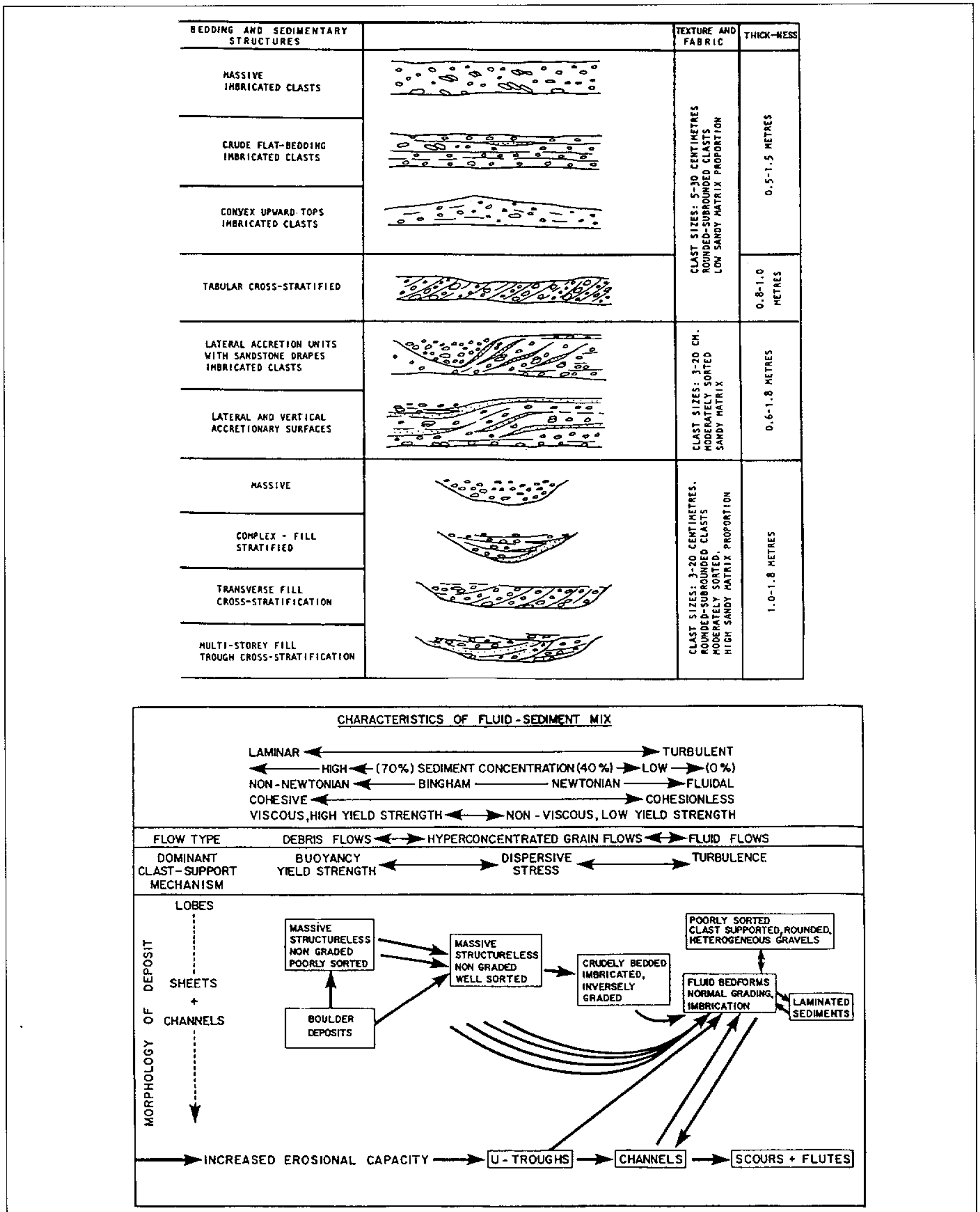

***Figure 3**. Fabric, stratification and crossbedding, and bedding styles in different types of gravels, with mechanisms and processes for their origins (modified from Miall, 1996).*

within gulches. In the mouths of tributaries entering either main valleys or major lakes, interglacial alluvial fans or fan-deltas formed. Locally some paleosols and overbank fines as well as organics may be preserved within the interglacial successions. In many of the sites a thick loess silt and organic succession of McConnell and younger age caps the glacial-interglacial cycles. Depending upon the local geomorphological history of a given site, one or more glacial-interglacial cycles could be preserved between bedrock and the youngest silt and peat deposits (Fig. 2). The basic stratigraphy is locally complicated by cryoturbation processes, including ice-wedges, frost-heave structures, load casts, and mass-flows and resedimentation associated with active layers and minor faults.

PRELIMINARY DISTINCTION OF INTERGLACIAL AND GLACIAL SEDIMENTS

It is difficult to distinguish glacial/glaciofluvial gravels from interglacial gravels without the aid of absolute or relative age-dating techniques. Coarse-grained sedimentary packages typically lack interbedded fines (that can be cored for magnetostratigraphic correlation) and organics (that can be used for radiocarbon dating or palynological analysis). Consequently, independent criteria are presently being assessed to aid in the distinction of these gravels (MacKinnon and Hein, in prep.). Some of these criteria are:

1. Lithology: Interglacial gravels tend to have clast lithologies that reflect local bedrock, and often indicate only a short-travelled distance from source. In regoliths and in lag gravels that have been weathered and reworked significantly prior to deposition and burial, the units are comprised mainly of resistant rock types, mainly vein quartz, chert, quartzite, siliceous siltstone, and locally-derived plutonic or mafic rock types. Valley-glacier sediments are also a reflection of local bedrock sources. Sediments derived from the Cordilleran ice sheet contain clasts that are more well-travelled and a consist of a suite of lithologies that are not found in the local bedrock of the drainage basin.

2. Roundness: Interglacial gravels tend to be more rounded within main valley fills, while gulch gravels, alluvial fan gravels and mass slope deposits tend to be more angular. Glacial and glaciofluvial gravels show a variety of rounding. If preglacial or interglacial fluvial gravels were reworked into the glacial ice or into the glaciofluvial outwash, the clasts may be rounded to well rounded. If clasts were derived by glacial ice plucking of bedrock they tend to very angular to angular depending upon the clast lithology. Some clasts within the glacial diamict show the triangular shapes characteristic of ventifacts. In general, glacial and glaciofluvial gravels tend to show a greater range of roundness of individual clasts within an individual deposit, in comparison with the interglacial gravels, which tend to be uniformly more angular or more rounded clasts within a single deposit.

3. Sorting: The grain size distribution of the sediment reflects the available grain size of material subject to the processes of transport and deposition as well as the surficial processes of erosion, transport and deposition (Fig. 3). If mass flows dominated in the erosion and transport of material in either an interglacial or glacial setting, the sediment that is deposited tends to be more poorly sorted. Similarly, if water-flow processes dominated the valley cut-and-fill processes either within interglacial fluvial settings or as glacial outwash /meltwater flows, the sediment will tend to be much more better sorted. Glacial-ice eroded and transported sediment tends to be very poorly sorted with a wide range of clast sizes (if all were available in the drainage system). Glacial-ice derived sediment may be a boulder-clay-sand-silt mixture (diamict), with the matrix size varying with the available material as well as the amount of water washing that may have affected the sediment prior to burial. Some glacial lake sediments that have direct input of glacial-ice material may show a boulder-clay or a cobble-gravel clay that reflects the size of material being dumped into the glacial lake by an advancing ice-tongue.

4. Fabric: Gravel fabric refers to the pattern of the gravel clasts as they were being deposited (Fig. 3). If deposition and burial was very rapid the gravel fabric may reflect the transport orientation of the clasts. If burial was less rapid, then significant surficial reworking may remould the gravel fabric prior to burial. By examining the gravel fabric, in association with other physical sedimentary structures, one can determine the mechanism of gravel deposition and the paleocurrent or paleodispersal pattern at the time of deposition. Mass flow processes in either glacial or interglacial settings may have random, disorganized or organized fabric patterns. Fluvial processes, by contrast, tend to better organize the gravel into distinct patterns that can be measured along with other physical sedimentary structures to determine bar and channel trends. In general, interglacial fluvial gravels show a well-organized pattern. If the gravels were emplaced as alluvial fans they may show a radial paleocurrent pattern; if they are within confined gulches or valleys a pattern reflecting down-valley transport is dominant. Braided channels, which occur on alluvial fans, in glacial outwash gravels or within valley deposits, tend to show complex paleocurrent patterns. Wandering or meandering gravel-bed deposits show a systematic paleocurrent pattern that reflects the meandering point bar-channel or wandering side-bar and channel system. Glacial-ice fabrics can be random, poorly organized or well organized, depending upon the local processes within the ice prior to deposition and burial. In all fabric and paleocurrent analysis the patterns must be put into both a spatial and temporal context to correctly ascertain the paleoflow and transport processes, as well as to aid in the paleoenvironmental interpretations.

5. Physical Sedimentary Structures: As with the gravel fabrics the physical sedimentary structures reflect the local sedimentary processes of deposition and burial of individual layers (Figure 3). The types of structures that are produced vary whether the gravels were emplaced from mass-flows, from water-flows or ice-flows. In general, water-lain gravels tend to show the

best stratification and crossbedding structures. It is very difficult to distinguish interglacial fluvial gravels from glaciofluvial outwash solely on the basis of physical sedimentary structures. These distinctions must be made in context with associated facies and geomorphological interpretations. In general, many of the interglacial gully and valley gravels tend to be within large-scale channel scours that reflect the ancient valley margins. If these valleys or gulches migrated through time, then these large cut-and-fill structures may outline separate periods of gulch or valley cut and fill. By contrast, most of the glaciofluvial outwash gravels observed in the study area lack these large cut-and-fill structures, and tend to only infill existing valleys. Mass-flow gravels show less well-developed stratification, and rarely crossbedding. The stratification tends to be parallel, and poorly developed. Some inverse-grading of fine-to-coarse sediment may occur at the base of individual debris flow beds. Other debris flow deposits may have the appearance of having "frozen in place, " showing large boulders, cobbles or pebbles sticking up above the individual bed level, protruding into the overlying succession. Glacial-ice derived gravels tend to be structureless, although internally there may have been some sorting or water-washing that leads to a very vague parallel stratification. Glaciolacustrine clays and silts often show a good parallel stratification, arranged into couplets of coarse-and-fine layers. Near ice-tongues or fronts, coarse-grained mass-flows or isolated "dropstones" may interfinger with the otherwise finely laminated silt and clay. Superimposed upon the entire suite of physical structures is the possible influence of cryoturbation and thermal karsting in areas of permafrost. These secondary physical structures include ice-wedge casts, ice-loading and flame structures, and complete mixing in areas of thaw mass flows. In general, these cryoturbation/thermokarst processes have greater effect on fine-grained overbank or organic sediments, although locally primary physical structures in gravels may also be disrupted.

Placer Deposits and Potential

Initial studies of the geomorphology of the known Mayo area placer deposits show that they occur in three main types of landforms of different ages (Tables 1, 2, 3). Alluvial fans and fan-deltas contain placer deposits that are either interglacial or post-McConnell in age. By contrast, valley-bottom placers are either glacial or glaciofluvial deposits of Reid age or older, or interglacial and Recent fluvial valley-fill and terrace deposits. These types of placers are best preserved near the maximum limit of glacial ice, where ice-scouring was minimal and depositional processes predominated. In the northwestern Mayo area, where the ice limits of both the Reid and McConnell glaciations occur in close proximity, significant buried paleoplacers may be preserved (Table 3).

Several Mayo area drainages within the study area have similar landforms and geologic settings as the documented placers in the Mayo area, and may be possible sites for placer deposits (Bond, this volume). Most of these creeks have not been extensively prospected. The Reid-age prospects include: canyon and/or valley-bottom deposits of Upper Davidson, Parent and Hope creeks; and alluvial fan deposits of Forty Pup, across Duncan Creek from Forty Pup, and Hope Creek (Fig. 1, Table 3). McConnell-age prospects are: canyon or valley-fills of Upper Faith, Allen, Christal, Dirksen, and Skate creeks; alluvial fans of Upper Faith and Allen creeks; fan-deltas at the mouth of Owl, Keystone, and Dirksen creeks; and meltwater channel deposits that drape bedrock terraces of Upper Duncan and Davidson creeks (Fig. 1, Table 3).

At present, sites in the Mayo study-area have geomorphic settings and stratigraphy indicating placer potential in a regional sense. The Mayo area however underwent periods of glaciation and deglaciation so that local sedimentological and stratigraphic features control the exact location and extent of placer deposits at a site-specific scale. The stratigraphic framework proposed here (Table 2) accounts for the complex and varied history of placer deposits in the multiply glaciated Mayo Mining District. Future fieldwork will address the local sedimentological and stratigraphic controls on placer potential within individual drainages.

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Table 2. Stratigraphic Framework

Landforms, associated deposits for the surficial sediment, and underlying major bedrock types that comprise the stratigraphic framework for the Mayo study area, central Yukon (modified from Bond, this volume; Doherty et al., 1993, Mougeot and Walton, 1996a, 1996b, 1996c; Murphy and Roots, 1992).

I. SURFICIAL DEPOSITS

QUATERNARY

Holocene - post-McConnell and Recent - Age: < 10.3 Ka (Interglacial)

Organic Deposits and Soils, Permafrost and Cryoturbation Deposits

Soils, fenland, peat, "muck", pingoes, thermokarst ponds and lakes, cryoturbation wedges, casts, surfaces, loads, diapirs, and cryoplanation terraces

Alluvial Deposits

Alluvial gulch, canyons, valley, plain, terrace, fans, deltas, lacustrine, and complexes

Colluvial Deposits

Colluvial veneer, felsenmeer, rock fall, talus, blanket, and complexes

Eolian Deposits

Eolian dunes, veneer, blanket, and complexes

PLEISTOCENE

Late Pleistocene - Late Wisconsinan -McConnell - Age: < 29 - 10.3 Ka (Glacial)

Glaciofluvial and Glaciolacustrine Deposits

Alluvial outwash valley, plain, terrace, fans, eskers, fan-deltas, lake-bottom blankets, and complexes

Glacial Deposits

Moraine (till) ridges, hummocky stagnation morraine, veneer, blankets, and complexes

Eolian Deposits

Loess veneer and blanket

Pre-Late Wisconsinan - Pre-McConnell <200 – 29 Ka (Interglacial)

Organic Deposits and Soils

Alluvial Deposits

Alluvial gulch, valley, plain, terrace, overbank, fans, fan-deltas, lacustrine, and complexes

Colluvial Deposits

Colluvial veneer, felsenmeer, rock fall, talus, blanket, and complexes

Middle Pleistocene - Illinoisan -Reid - Age: > 200 Ka (Glacial)

Glaciofluvial and Glaciolacustrine Deposits

Alluvial outwash valley, plain, terrace, fans, eskers, fan-deltas, lake-bottom blankets, and complexes

Glacial Deposits

Moraine (till) ridges, hummocky stagnation morraine, veneer, blankets, and complexes

Illinoisan - Reid (Interglacial)

Organic Deposits and Soils

Alluvial Deposits

Alluvial gulch, valley, overbank

Colluvial Deposits

Colluvial veneer, felsenmeer, rock fall, talus, blanket, and complexes

Early Pleistocene - Undifferentiated pre-Reid - Age: > 1.4 Ma

Pre-Reid (Glacial)

Glaciofluvial and Glacial Deposits

Alluvial outwash valley, plain, terrace, moraine (till) ridges, morainal blanket, and complexes

Pre-Reid (Interglacial)

Alluvial Deposits

Alluvial gulch, valley, overbank

Colluvial Deposits

Colluvial veneer, felsenmeer, rock fall, talus, blanket, and complexes

PLIOCENE- EARLY PLEISTOCENE - Undifferentiated - Age: Unknown (Interglacial or Preglacial)

Alluvial Deposits

Alluvial gulch, valley, overbank

Colluvial Deposits

Colluvial veneer, felsenmeer, rock fall, talus, blanket, and complexes

Cryoturbation Deposits

Cryoturbation wedges, casts, surfaces, loads, diapirs, and cryoplanation terraces

II. MAJOR BEDROCK TYPES

CRETACEOUS

Rhyolite and trachyte

Small intrusions, dykes and sills

Biotite hornblende granite, quartz monzonite

Larger intrusions, plutons, plugs and dykes, including those at Roop Lakes, Scheelite Dome, Potato Hills and Mount Haldane, Two Buttes plug.

TRIASSIC AND ? JURASSIC

Hornblende-clinopyroxene diorite to gabbro

Foliated meta-diorite and minor mafic sills

Slate, siltstone, sandstone, with minor limestone

Recessive fine-grained clastic rocks, including buff to grey weathering calcareous slate and dark grey, finely crystalline limestone

MISSISSIPPIAN

"Keno Hill quartzite"

Quartzite, schist, phyllite, with metadiorite

Dark grey, thick-bedded to massive, quartzite, with minor interbeds of carbonaceous schist and lenses of chloritic phyllite, with small metadiorite intrusives.

UPPER DEVONIAN AND MISSISSIPPIAN

Earn Group

Chert-pebble conglomerate, grit, sand-, silt- and mudstone, with minor breccia and limestone

Upper part: black and dark brown weathered chert-pebble conglomerate, sandstone and chert grit, with minor interbedded light grey-weathering fissile mudstone and buff sandstone.

Lower part: black siltstone and mudstone, with minor chert-pebble conglomerate lenses and breccia, and minor black to dark grey limestone; at base minor fine grained, brown-weathered sandstone and siltstone with chert pebbles.

CAMBRIAN (?) TO LOWER DEVONIAN (?)

Road River Group

Chert, mudstone, with siltstone

Light grey to blue-weathered, black or light grey chert, interbedded with black mudstone, and dark brown to black quartz siltstone.

MIDDLE ORDOVICIAN (?)

Olive to brown-weathered laminated siltstone, brown sandstone with thin interbeds of black bioturbated chert.

UPPER PROTEROZOIC (?) AND LOWER CAMBRIAN (?)

Hyland Group

Mudstone and siltstone, with sandstone; metasandstone, phyllite, with limestone; schist, slate, metadiorite

Maroon and green mudstone and siltstone, with quartz sandstone interbeds

Grey-weathered, fine to coarse quartz metasandstone, locally calcareous, with pale grey to green phyllite. Minor white to grey crystalline limestone and phyllitic limestone.

Brown-weathered, medium to coarse quartz mica schist.

Dark brown-weathered, black carbonaceous slate, with minor interbedded dark grey quartzite.

Chloritic phyllite and metadiorite.

Table 3. *Summary of known and potential placers, Mayo area, central Yukon, with age of host sediment, orientation of the drainage with respect to the regional glacial ice-transport direction, and gold size and fineness. (Placer Mining Section 1996).*

Creek Name	Landform	Glacial-age	Direction to Ice-Flow	Gold Size & Fineness
Empire	Canyon	McConnell	055 degrees	very coarse - 910
Steep	Fan-delta	McConnell	120 degrees	coarse - 946
Ledge	Fan-delta	McConnell	100 degrees	fine to coarse - 825
Anderson	Fan-delta	McConnell	090 degrees	fine to coarse - 870
Davidson	Canyon	McConnell	120 degrees	fine - 840
Duncan	Valley	McConnell	090 degrees	fine to coarse - 850
Owl	Fan-delta	McConnell	085 degrees	unknown - potential
Keystone	Fan-delta	McConnell	090 degrees	unknown - potential
Upper Faith	Valley & Alluvial Fan	McConnell	090 degrees	unknown - potential
Allen	Valley & Alluvial Fan	McConnell	090 degrees	unknown - potential
Christal	Valley & Canyon	McConnell	000 degrees	unknown - potential
Dirksen	Valley & Fan-delta	McConnell	090 degrees	unknown - potential
Upper Duncan Terrace	Meltwater Channel	McConnell	000 degrees	unknown - potential
Skate	Canyon & Valley	McConnell	090 degrees	unknown - potential
Williams	Alluvial Fan	Reid	090 degrees	rare fine -
Upper Duncan	Valley	Reid	000 degrees	fine to coarse-
Thunder	Valley	Reid	000 degrees	fine to coarse- 823
Lightning	Valley	Reid	000 degrees	fine to coarse- 823
Parent	Valley	Reid	090 degrees	unknown - potential
Forty Pup	Alluvial Fan	Reid	090 degrees	unknown - potential
Across Forty Pup	Alluvial Fan	Reid	090 degrees	unknown - potential
Hope	Valley & Alluvial Fan	Reid	090 degrees	unknown - potential
Upper Davidson	Canyon & Valley	Reid	000 degrees	unknown- potential

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Appendix A

Heavy Mineral Investigation (1995): Preliminary Results, Mayo Area Placer Project

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INTRODUCTION

This report presents results from an investigation of the heavy mineral content of samples collected from the Mayo area of Yukon Territory. The samples were collected during the 1995 field season as part of a placer research project in the Mayo Mining District. The project was funded and managed by the Yukon Geology Program. Walton Geological Services of Whitehorse, Yukon was commissioned to extract and study the heavy mineral fraction of the sample suites.

The goal of the study was to examine, on a reconnaissance scale, the heavy mineral fraction of samples collected from a variety of settings (gravel over bedrock, soil samples, colluvium, placer bench, etc.) and link the heavy minerals, particularly any metallic ones, to mineral showings of economic interest. In addition, study of the heavy mineral fraction provides information on the stratigraphy and sedimentology of the area.

A conclusive heavy mineral study, of the type produced by Gleeson (1970) for the Klondike area, was beyond the scope of this study. In the study by Gleeson, sophisticated laboratory equipment, such as a Frantz separator was used for the heavy mineral separation. Grain mounts were made of each sample, and X-ray diffraction and chemical treatments were used for mineral identification. For the 1995 Mayo Placer Project heavy mineral study, simple mineral extraction and mineral identification techniques were used. The cost-effective methodology developed for this study can be adopted by prospectors and exploration geologists interested in using heavy mineral analysis as an exploration tool. With the exception of 16 mineral grains which were sent for microprobe analysis, all mineral identifications in this study should be considered tentative, until confirmed by more sophisticated equipment.

METHODOLOGY

Samples for the study were collected during the 1995 field season. The samples were dry sieved during the summer of 1996 and the different size fractions were weighed and then stored. For this heavy mineral study, the size fractions between -18 to -60 mesh were recovered and processed.

Sample Processing and Extraction of Heavy Minerals

A total of 41 samples from three sample suites from were processed at the core library (Exploration and Geological Services Division - Department of Indian and Northern Affairs) facility in Whitehorse, Yukon.

The following procedure was followed:

1. The -18 mesh, -36 mesh and -60 mesh size fractions were combined and put into a black plastic goldpan.
2. The -18 mesh to -60 mesh fraction was panned down by hand to between 3 to 20 grams (approximately) of heavy mineral concentrate.
3. Each pan concentrate was checked for gold content before removal from the goldpan.
4. The pan concentrate was allowed to dry on a coffee filter perched on top of a paper plate.
5. The coffee filter containing the dried pan concentrate was used as a funnel to shepherd the concentrate into a small beaker containing methylene iodide. This procedure was carried out under a fume hood.
6. Minerals or rock fragments with a specific gravity greater than 3.32 sink to the bottom of the beaker.
7. Minerals or rock fragments with a specific gravity less than 3.32 float on the surface of the methylene iodide and are removed with a spoon or are poured off.
8. The remaining heavy mineral grains and rock fragments in the bottom of the beaker (those with specific gravity greater than 3.32) are rinsed with ethyl alcohol and flushed out to dry on filter paper set on a paper plate.
9. When dry, the filter paper is used as a trough to get the >3.32 fraction into a labeled glass vial.

Note 1. Methylene Iodide should be used under a fume hood. The rinsed portion of methylene iodide and alcohol was placed in a separating funnel and the methylene iodide was recovered for re-use.

Note 2. The above method does not produce a completely "clean" heavy mineral concentrate, but was perfectly adequate for the purpose of this study. Gleeson (1970) recommends using a set of sluice boxes to produce a concentrate then using bromoform, a hand magnet and a Frantz isodynamic separator to remove the heavy minerals.

Note 3. It should be noted that the >3.32 mineral fraction also includes rock fragments. In some cases, rock fragments, as opposed to individual mineral grain, made up almost 100% of the sample.

Examination of Heavy Mineral Fraction

All microscope work was carried out at the Yukon Geology Program office in Whitehorse, Yukon. The following equipment was used:

- binocular microscope
- longwave and shortwave ultraviolet light
- penlight and handheld microscope with micrometer (for measuring the size of individual grains).
- wine cork with needle stuck in it (the most used piece of equipment - for moving around mineral grains)
- fine-tipped tweezers
- variety of magnets
- dilute HCl
- dichroscope for determining pleochroism
- stainless steel pushpin (for scratch tests) and hardness points

The heavy minerals recovered from the samples were examined using the following procedure:

1. The >3.32 fraction was placed on black construction paper and examined under the binocular microscope.
2. The room lights were then turned off and the sample was examined under longwave and shortwave ultraviolet light. Due to the extremely small size of the mineral grains, the sample was aligned in the binocular microscope, and any fluorescence was observed under magnification by holding the ultraviolet light source as close as possible to the sample.
3. The room lights were turned back on and the sample was then placed on white paper.
4. The magnetite fraction was removed and the remaining mineral grains were examined.
5. If warranted, the <3.32 fraction was also looked at.

Mineral identification was difficult due to the very small size of most mineral grains, which was, on average, less than 1.0 mm. Mineral identification was done using basic techniques (ultraviolet light, magnification, magnetism, crystal form).

PROJECT RESULTS

Table 1 lists the percentages of the more common heavy minerals noted in the sample sets. Notes on the heavy-mineral characteristics of each sample follow:

Heavy Mineral Identification Notes: Mayo Placer Project – 1995 Samples

FT2-95-1/1 Duncan Creek Section 2 Unit 1 (bottom)

Very interesting sample due to the presence of euhedral arsenopyrite crystals with striated faces. Some of the arsenopyrite crystals are in quartz matrix. There is abundant limonite coated pyrite. Five small grains of scheelite were noted under shortwave ultraviolet light. Also 5-10% of the sample consists of fresh, euhedral unoxidized pyrite. About 1-5% of the pyrite shows a purple iridescent tarnish. One brownish yellow striated twinned crystal which might be cassiterite was observed. Orange-yellow limonite-coated grains comprise 10-20% of the sample.

FT2-95-1/2 Duncan Creek Section 2 Unit 1 (top)

Mainly rock fragments. Four rounded nuggets of gold from 1.0 mm to <0.2 mm.

FT295-2 Duncan Creek Section 2 Unit 2

Mainly rock fragments.

FT2-95-3 Duncan Creek Section 2 Unit 3

Mix of many different mineral and rock grains. Abundant rock fragments.

FT2-95-5 Duncan Creek Section 2 Unit 5

Grain size of sample is consistent. Under ultraviolet light, there are 20 small grains which fluoresce moderate green-yellow under both longwave and shortwave light. The grains are white to clear in overhead light, tabular, and display at least one good cleavage. Might be celestite? (SrSO4).

FT2-95-7 Duncan Creek Section 2 Unit 7

Mainly rock fragments, ilmenite.

FT2-95-9 Duncan Creek Section 2 Unit 9

Ilmenite, nice gemmy pink garnets.

FT2-95-10 Duncan Creek Section 2 Unit 10

Very low heavy mineral yield.

FT2-95-13 Duncan Creek Section 2 Unit 13

Mainly light colored minerals and rock fragments. Also get 1-2% euhedral fresh to slightly oxidized pyritohedrons.

FT3-95-1/1 Duncan Creek Section 3 Unit 1 (pay)

Many grains are coated with limonite. The two gold grains are rounded and flattened. There is one grain which fluoresces blue-white under both longwave and shortwave ultraviolet light. Under visible light the same grain is a very thin white plate which is sectile and has a pearly lustre - brucite?

FT3-95-1/1 Duncan Creek Section 3 Unit 1 (pay) bottom

Pyritiferous concentrate. Sample contains 10-20% platy black mineral with white alteration rim; this is most likely a leucoxene coating on ilmenite. Leucoxene is an amorphous chemically variable titanium oxide which is gray to white and forms as a result of alteration of titanium rich minerals. Between 10 to 15 grains fluoresce medium-faint white, slightly blue under longwave and shortwave ultraviolet light and are white under visible light (mineral is unidentified). The <3.32 fraction contains abundant pyrophyllite? or talc?.

FT3-95-1/2 Duncan Creek Section 3 Unit 1 Area 2

One thin flake gold.

FT3-95-1/3 Duncan Creek Section 3 Unit 1 Area 3

Three flat, rounded gold flakes; the largest is .05 mm.

FT3-95-1/4 Duncan Creek Section 3 Unit 1 Area 4

Abundant ilmenite. Garnet is the next most abundant mineral (5-10%), then magnetite (2-4%). Trace amounts of zircon and pyrite were noted. This sample strongly resembles FT3-95-1/5 and FT3-95-1/6.

FT3-95-1/5 Duncan Creek Section 3 Unit 1 Area 5

This sample is very similar to FT3-95-1/4 and FT3-95-1/6.

FT3-95-1/6 Duncan Creek Section 3 Unit 1 Area 6

Sample is very similar to FT3-95-1/4 and FT3-95-1/5.

FT4-95-1 Duncan Creek Section 4 Unit 1 - organic?

Up to 10% limonite. There is 5-15% pyrite content, of which 2-5% are goethite/hematite pseudomorphs after pyrite.

FT4-95-5 Duncan Creek Section 4 Unit 5 - organic?

Very low yield. Mainly rock fragments.

FT8-95-1 Duncan Creek Bend section lower unit

Sample consists mainly of rock fragments and ilmenite, with minor magnetite. There are two gold grains; one is a flattened leaf, relatively crystalline. The other gold grain is elongated leafy gold, relatively crystalline, perched on a limonite-coated, rusty mineral grain (pyrite?).

FT8-95-7 Duncan Creek Bend section contact lower/upper till

Resembles other Duncan Creek samples (ilmenite, minor magnetite); noted 1 small bright scarlet red grain (unidentified).

FE1-95-1 Highet Creek F. Erl Unit 1 - Orange gravel

Ilmenite-rich. Mineral grains are coated with limonite.

FE1-95-2 Highet Creek F. Erl Unit 2 - Organic silt

Sample is composed of mostly tabular ilmenite grains.

FE1-95-3 Highet Creek F. Erl Unit 3

Sample is 80-95% ilmenite.

HB2-95-1 Upper Duncan Creek Barchans old cut - multiple tills

Very interesting sample. Mainly ilmenite and magnetite, but also get pyrite and an unidentified grey sulphide mineral.

HB2-95-2 Upper Duncan Creek Barchans old cut - multiple tills

Varied mix of minerals and rocks. Garnet, ilmenite, rock fragments.

HB2-95-3 Upper Duncan Creek Barchans old cut - multiple tills

Mix of minerals and rock fragments. Same as HB2-95-2.

HT3-95-1 Highet Creek Bend section near old cabin

Mainly ilmenite and magnetite. There are five subrounded to rounded flattened gold grains; the largest is 0.06 mm.

HB4-95-1 Upper Duncan Creek Canyon Section Gravel

Contains 2-3% pyrite, 20-50% ilmenite.

KK1-95-1 Highet Creek Klippert Unit 1

There are 20 gold grains (about 1% of sample). The largest gold grain is 1 mm and very flat. The gold grains are subcrystalline to subrounded. There are 25 grains scheelite (about 1% of sample). The sample is mainly composed of ilmenite (90-95%). Approximately 10% of the ilmenite is coated by leucoxene.

KK1-95-2B Highet Creek Klippert Unit 2

Almost 100% tabular ilmenite.

KK1-95-3 Highet Creek Klippert Unit 3

Mainly ilmenite, trace oxidized pyritohedrons.

DC1-95-1 Duncan Creek 40 Pup Bench Unit 1

Ilmenite, trace goethite/hematite psuedomorphs after pyrite.

DC1-95-2 Duncan Creek 40 Pup Bench Unit 2

Very low yield.

MP1-95-1 Highet Creek Merrill Powers Pit Unit 1 clay/bedrock

Mostly limonite coated rock fragments.

MP1-95-2 Highet Creek Merrill Powers Pit Unit 2 - Pay gravel

Gold grains comprise 5-15% of the sample; the largest grain is 2 mm. Most of the gold grains are flat and rounded; some are subrounded. One scheelite grain and small zircon grains are visible under ultraviolet light. Schistose rock fragments comprise 10-20% of the sample.

DK1-94-1A Seattle Creek Dan Klipperts
Gold grains are up to 1.2 mm and are sub-rounded.

DK1-94-1B Seattle Creek Dan Klipperts
Mostly rock fragments and ilmenite.

DK1-95-1 Seattle Creek Rusty gravel Unit 1
Abundant rock fragments; mainly mafic schist. Sample is black and yellow and exhibits a "salt and pepper" look. One grain is intense white-green under longwave and moderate under shortwave. In visible light, the grain is white, platy, friable (brucite?, talc?).

RB1-95-1B Ledge Creek sed sample
The sample size was very small. No magnetite was recovered. Most of the grains are rock fragments; mainly mafic schist. One 0.03 mm scheelite grain was visible under ultraviolet light. There is one brownish yellow transparent to translucent twinned crystal (unidentified).

HIGHLIGHTS OF HEAVY-MINERAL RESULTS

In general, the heavy minerals observed in samples collected in 1995 from the Mayo Mining District River area show some variety in the degree of homogeneity of samples and in the angularity of the mineral grains. Many samples contain mostly euhedral heavy minerals or angular heavy mineral fragments indicating a nearby bedrock source. Rock fragments were abundant. The most abundant heavy minerals were magnetite, garnet and ilmentite in varying proportions. Samples from Highet Creek contain the most ilmenite.

- A total of 10 samples out of 41 samples contain gold grains:

Sample Number	Number of Gold Grains
FT2-95-1/2	4
FT3-95-1/1	2
FT3-95-1/2	1
FT3-95-1/3	3
FT8-95-1	2
HT3-95-1	5
KK1-95-1	20
MP1-95-2	39
DK1-94-1A	4

Most gold grains observed are rounded nuggets with little or no crystal form. Sample FT8-95-1 contains two gold grains; one is a 0.2 mm flattened leaf, relatively crystalline with jagged, irregular edges and the other is elongated leaf gold perched on a limonite-coated oxidized mineral grain (pyrite?). Both samples are bright yellow, very fresh looking and may indicate a gold-bearing vein deposit nearby.

- Metallic heavy minerals were relatively rare, except for pyrite and geothite/limonite/hematite pseudomorphs after pyrite. Pyrite occurs in trace (<1%) amounts in many of the samples, and comprises 80-90% of sample FT3-95-1/1. Some pyrite grains from the Mayo often showed extensive oxidation. The microprobe study confirmed that pyrite in many samples had been replaced by a hematite/goethite combination. These pseudomorphs after pyrite form cubes, pyritohedrons or anhedral blebs. Fresh, lustrous, untarnished pyrite was noted in samples FT2 -95-1/1 and in FT3-95-1/1.
- Sample FT2-95-1/1 contains euhedral striated arsenopyrite crystals up to 1.5 mm. Some of the arsenopyrite is in quartz matrix, and some is associated with pyrite. This sample also contains trace amounts of scheelite. A bedrock source for the arsenopyrite and pyrite in this sample must be close to the sample site.
- Sample HB2-95-2 contains ilmenite, magnetite, pyrite and a grain of galena.
- Sample KK1-95-1 contains abundant ilmenite, 20 grains of gold and 1% scheelite.

SUMMARY

Heavy minerals were extracted from a total of 41 samples collected in 1995 for the Mayo Mining District Placer Research Project.

Magnetite, garnet and ilmenite are the most abundant heavy minerals in the study. Significant other minerals include pyrite/goethite, staurolite, sphene, rutile, epidote, zircon, scheelite and hypersthene. Arsenopyrite was noted in one sample and galena was noted in one sample.

A total of 10 samples contain gold grains. Most gold grains are rounded placer nuggets with the exception of sample FT8-95-1. There are two grains of delicate leaf gold in sample FT8-95-1, one of which is perched on matrix. There may be a nearby vein source for this gold. Sample FT2-95-1/1 contains euhedral, unoxidized arsenopyrite and pyrite crystals, indicating a very close-by bedrock source for these minerals.

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***Table 1. Mayo Area Placer Project** Heavy Mineral Content (1995 Samples)*

Sample Number	Creek	Sample Location	Yield	Gold	Mag	Grnt	Py	Hem	Ilm	Sch	Zir	Cass	Blk Min	Lt Min	Rk Frag
FT2-95-1/1	Duncan	Section 2 Unit 1 (bottom)	H		10-20%	5-10%	5-10%	<1%		Tr		Tr	10-30%	5%	30-60%
FT2-95-1/2	Duncan	Section 2 Unit 1 (top)	L	4 gr.	2-5%	2-5%	Tr		Tr				10-30%	5%	50-70%
FT2-95-2	Duncan	Section 2 Unit 2	L		Tr	2-3%			2-5%			Tr	10-30%	5%	50-70%
FT2-95-3	Duncan	Section 2 Unit 3	L		<1%	5-20%		Tr	10-20%			5%	10-20%	1-5%	20-40%
FT2-95-5	Duncan	Section 2 Unit 4	M		<1%	25-40%		1%	5-10%			1-2%	20-30%	1-5%	20-40%
FT2-95-7	Duncan	Section 2 Unit 7	L		2-5%	2-3%			5-10%					1-5%	40-60%
FT2-95-9	Duncan	Section 2 Unit 9	L		2-3%	10-20%			20-40%				5-10%	2-5%	20-40%
FT2-95-10	Duncan	Section 2 Unit 10	L		Tr	10-20%			20-40%			Tr	5-10%	2-5%	20-40%
FT2-95-12	Duncan	Section 2 Unit 12	L		1-2%	2-5%			10-20%				5-10%	50-70%	20-30%
FT2-95-13	Duncan	Section 2 Unit 13	L		1-2%	2-5%			20-40%				5-10%	30-50%	30-50%
FT3-95-1/1	Duncan	Section 3 Unit 1 (pay)	L	2 gr.	2-3%	5-15%	Tr		20-40%		Tr	Tr	10-20%	1-3%	20-40%
FT3-95-1/1	Duncan	Section 3 Unit 1 (pay) bottom	M			<1%	80-90%				Tr		1-5%		1-5%
FT3-95-1/2	Duncan	Section 3 Unit 1 - area 2	L	1 gr.	<1%	5-15%	Tr		5-20%		Tr		10-30%		30-50%
FT3-95-1/3	Duncan	Section 3 Unit 1 - area 3	L-M	3 gr.	<1%		Tr	Tr	10-30%		<1%		20-40%		20-40%
FT3-95-1/4	Duncan	Section 3 Unit 1 - area 4	L		2-4%	5-10%	Tr		20-40%		Tr		20-40%		10-30%
FT3-95-1/5	Duncan	Section 3 Unit 1 - area 5	M		2-4%	5-10%	Tr		20-40%		Tr		20-40%		10-30%
FT3-95-1/6	Duncan	Section 3 Unit 1 (pay) top	L		2-4%	5-10%	Tr		20-40%		Tr		20-40%		10-30%
FT4-95-1	Duncan	Section 4 Unit 1 - organic?	M		1-2%	2-3%	5-15%		30-50%				10-20%	5-10%	30-40%
FT4-95-5	Duncan	Section 4 Unit 5 - organic?	L		Tr						Tr				95-100%
FT8-95-1	Duncan	Duncan Creek bend section lower unit	L	2 gr.	1-2%				10-20%		Tr		15-30%		40-60%
FT8-95-7	Duncan	Bend section contact lower/upper till	L		1%	5%			5-10%				15-30%		40-60%
FE1-95-1	Highet	F. Erl Unit 1 - Orange gravel	M		2-5%				80-95%						5-10%
FE1-95-2	Highet	F. Erl Unit2 - Organic silt	M						95-99%				1-2%		1-2%
FE1-95-3	Highet	F. Erl Unit 3	L						80-95%				1-2%	1-2%	10-20%
HB2-95-1	U. Duncan	Barchans old cut - multiple tills	L		10-25%		1%		5-15%				40-60%		10-30%
HB2-95-2	U. Duncan	Barchans old cut - multiple tills	L		5-15%	5-10%			5-15%		Tr		10-30%	10-15%	20-40%
HB2-95-3	U. Duncan	Barchans old cut - multiple tills	L		5-15%	5-10%			5-15%		Tr		10-30%	10-15%	20-40%
HB4-95-1	U. Duncan	Upper Duncan canyon section gravel	M		5-10%	2-3%	2-3%		20-50%			Tr	5-10%	5-10%	20-40%
HT3-95-1	Highet	Highet Creek bend sect. near old cabin	L-M	5 gr.	10-15%				50-80%				5-10%		
KK1-95-1	Highet	Highet Creek Klippert Unit 1	M	20 gr.	1-2%				90-95%	1%	Tr	Tr	5-10%		
KK1-95-2B	Highet	Highet Ck. Klippert Unit 2	M		1-2%				90-95%				1-2%	1-2%	1-2%
KK1-95-3	Highet	Highet Ck. Klippert Unit 3	M		2-10%		Tr		60-80%				2-5%	2-5%	20-40%
DC1-95-1	Duncan	40 pup bench Duncan Unit 1	L		Tr	2-5%			30-60%				5-10%	5-10%	40-70%
DC1-95-2	Duncan	40 pup bench Duncan Unit 2	L		Tr	Tr			30-60%		Tr		5-10%	5-10%	40-70%
MP1-95-1	Highet	Merrill Powers Pit Unit 1 clay/bedrock	L		Tr	Tr	Tr		1%	Tr			5%		90-95%
MP1-95-2	Highet	Merrill Powers Pit Unit 2 - Pay gravel	L-M	39 gr.	3%	1%				Tr	Tr	1-2%			90-95%
DK1-94-1A	Seattle	Dan Klipperts	L	4 gr.	5-10%	2-3%	Tr		5-15%				1-2%	5-10%	80-90%
DK1-94-1B	Seattle	Dan Klipperts	L		2-10%	1-2%	Tr		40-60%				2-3%	2-3%	40-60%
DK1-95-1	Seattle	Rusty gravel unit 1	L-M		5%				25-35%			Tr	5%		50-70%
RB1-95-1B	Ledge	Ledge Creek sed sample	L						5-10%	Tr			5%		80-95%

Yield of heavy minerals (estimate only): High (H) = 200 milligrams or greater, Medium (M) = 50 to 200 milligrams, Low (L) = less than 50 milligrams recovery

Gold: The column shows the total number of induviduai gold grains counted in each sample.

Mag: Magnetite — Grnt: Garnet — Sch: Scheelite
Lim: Limonite — Py: Pyrite — Zir: Zircon
Blk Min: Unidentified black minerals — Hem: Hematite — Cass: Cassiterite
Lt Min: Unidentified light minerals — Ilm: Ilmenite — Rk Frag: Rock Fragments

The Glacial History and Placer Gold Potential of the North McQuesten River(116A/1), Dublin Gulch (106D/4), and Keno Hill (105M/14) Map Areas, Mayo Mining District, Central Yukon

Jeffrey D. Bond[1]

BOND, J.D. 1997. The Glacial History and Placer Gold Potential of the North McQuesten River(116A/1), Dublin Gulch (106D/4) and Keno Hill (105M/14) map areas, Mayo Mining District, Central Yukon. In: LeBarge, W.P. and Roots, C.F., (editors), 1997. Yukon Quaternary Geology, Volume 2, Exploration and Geological Services Division, Northern Affairs Program, Yukon Region, p.30-43.

ABSTRACT

Glacial history reconstructions and geomorphic mapping in the North McQuesten River, Dublin Gulch, and Keno Hill map areas indicate a succession of less extensive glaciations. From oldest to youngest the main glacial episodes are the pre-Reid (multiple glacial episodes), Reid and McConnell glaciations. The surficial geology of the study area is dominated by deposits of the Reid and McConnell glaciations. Pre-Reid glacial deposits are mostly confined to infrequent erratics on plateau areas above the Reid glacial limit. Glacial limit mapping indicates that ice flow patterns were similar in both the Reid and McConnell glaciations. Valleys aligned parallel with glacial ice flow are broad and U-shaped with significant glacial deposits in valley bottoms. In contrast, valleys aligned transverse to glacial ice flow are narrower and have a more V-shaped morphology. This relationship appears to be a controlling factor on the distribution of placers in the study area. Numerous drainages were analyzed for their placer potential in each of the three map areas. Their potential was based on geomorphic evaluations, glacial history, geochemistry, bedrock geology, and historic records. A concentration of potential placer creeks were identified in the Keno Hill/Mayo Lake area. Fewer prospective creeks were identified in the Dublin Gulch and North McQuesten River map areas.

RÉSUMÉ.

Les reconstitutions de l'histoire glaciaire et la cartographie géomorphologique des régions cartographiques de la rivière North McQuesten, de Dublin Gulch et de Keno Hill indiquent qu'il y a eu succession de glaciations de moins en moins étendues. Du plus ancien au plus récent les principaux épisodes glaciaires sont respectivement les épisodes pré-Reid (épisodes glaciaires multiples), Reid et McConnell. La géologie de surface de la région étudiée est dominée par les dépôts des glaciations de Reid et McConnell. Les dépôts glaciaires pré-Reid sont constitués essentiellement de rares blocs erratiques dans des régions de plateau situées au-dessus de la limite de l'épisode de Reid. La cartographie des limites d'extension glaciaire indique que les configurations d'écoulement glaciaire des épisodes de Reid et de McConnell sont semblables. Les vallées alignées parallèlement à la direction d'écoulement glaciaire sont larges et en forme de U et leur fond renferme d'importantes quantités de sédiments glaciaires. Par contraste, les vallées transversales à la direction d'écoulement glaciaire sont plus étroites et ont un profil se rapprochant plus d'une forme en V. Cette opposition semble être un facteur déterminant pour la répartition des placers dans la région étudiée. Le potential en placers de plusieurs bassins versants a été analysé dans chacune des trois régions cartographiques. Leur potentiel a été évalué selon la géomorphologie, l'histoire glaciaire, la géochimie, la géologie du substratum rocheux et les données historiques. Une concentration de ruisseaux placériens potentiels a été identifiée dans la région de Keno Hill/lac Mayo. Moins de ruisseaux promettres a été identifié dans les régions cartographiques de Dublin Gulch et de la rivière North McQuesten.

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INTRODUCTION

Glacial history reconstructions and geomorphic mapping were completed in three 1:50,000 scale map sheets in the Mayo Mining District to evaluate the placer potential of creeks adjacent to areas being currently mined or that are recognized as traditional sites. The surficial geology of the North McQuesten River, Dublin Gulch, and Keno Hill map areas suggest a multiple glacial history similar to other regions of the central Yukon. From oldest to youngest the main glacial episodes include the pre-Reid (multiple glacial episodes), Reid, and McConnell glaciations. This research aims to understand how these major cycles of glacial erosion and deposition have influenced the landscape by determining the drainage controls and interpreting the stratigraphy of glacial deposits. These studies, combined with a knowledge of bedrock geology, stream sediment geochemistry and historic records, constitute the basis for placer exploration at both regional and local scales. This paper summarizes the glacial history of the region north of Mayo, Yukon and discusses the placer gold potential of some of the more prospective drainages in this area. The paper represents results from the first season of research in 1996; research will resume in the summer of 1997.

Location of Study Area

The Mayo Mining District is located in central Yukon, approximately 400 km by road north of Whitehorse (Figure 1). From the village of Mayo all-weather roads extend to the hamlet of Keno City near the centre of Keno Hill map area (105M/14) and to Dublin Gulch in the southern part of Dublin Gulch map area (106D/4). No roads enter North McQuesten River map area (116A/1), which is 10 km west of Dublin Gulch (Fig.1).

REGIONAL GEOLOGY AND PHYSIOGRAPHY

The study area is located in the Stewart Plateau physiographic division (Mathews, 1986), northeast of the Tintina Trench in central Yukon. Map areas 116A/1 and 106D/4 are positioned at the northern margin of the plateau, south of the Ogilvie Mountains, and 105M/14 includes the mountainous Gustavus Range north of Mayo Lake (Fig. 1).

North McQuesten River Map Area (116A/1)

The North McQuesten River map sheet is dominated by upper Proterozoic - lower Cambrian Hyland Group rocks (Murphy and Héon, 1994). In Seattle Creek map area (115P/16), to the south,

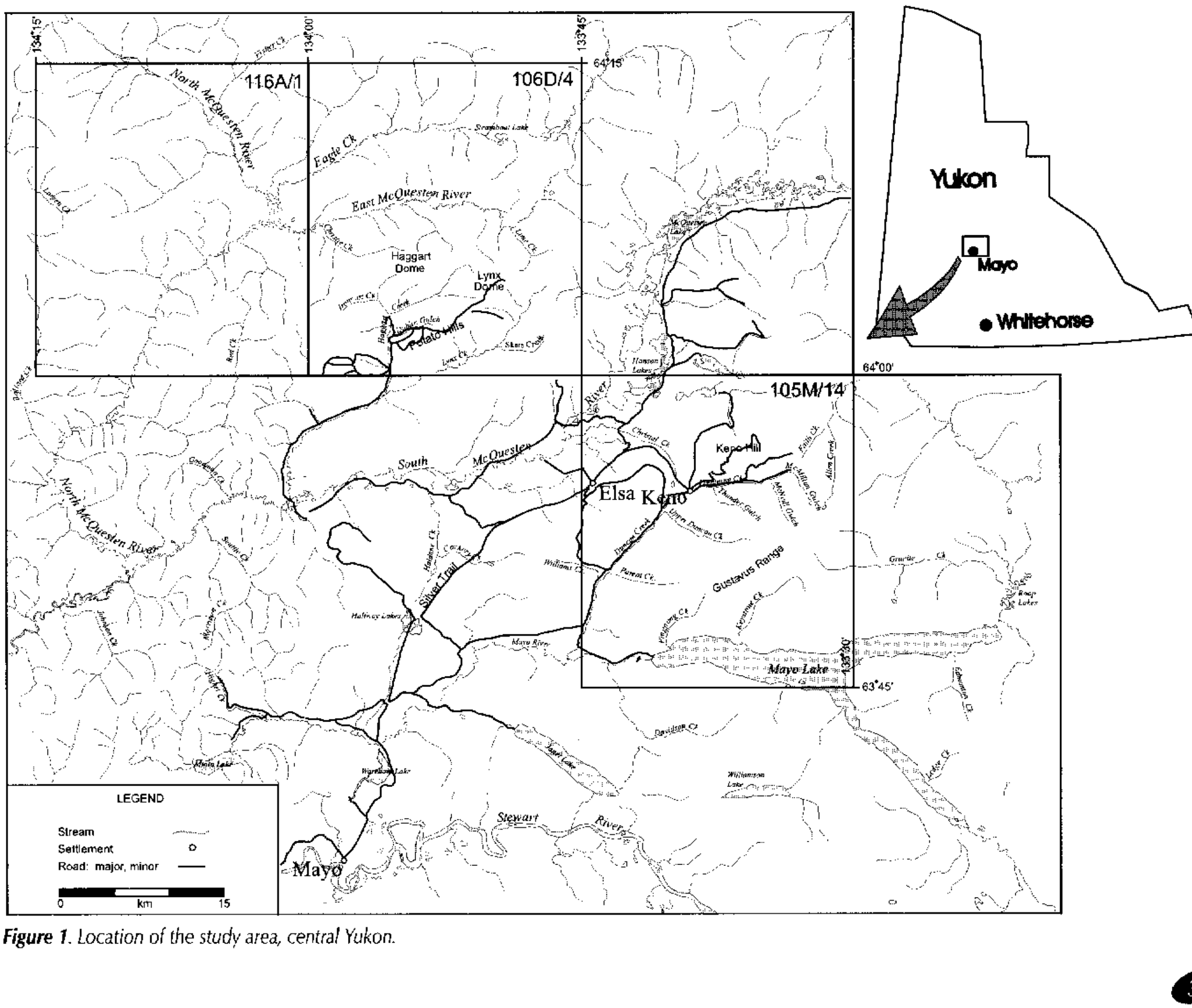

Figure 1. Location of the study area, central Yukon.

the Hyland Group is divided into two formations: the Yusezyu and the Narchilla (Murphy and Héon, 1994). The older Yusezyu formation comprises predominantly phyllite, metasiltstone, medium to course grained metasandstone, metaconglomerate, and sandy marble, whereas the Narchilla formation includes quartzofeldspathic sandstone, maroon and green argillite, and grey, weathered, marble (Green, 1971; Murphy and Héon, 1994). The northern limit of Hyland Group, the Robert Service Thrust, is parallel to the north edge of the map area.

The physiography of the North McQuesten River map area is dominated by the south-flowing North McQuesten River valley. Highlands in the north part of the map sheet represent the southern fringe of the Ogilvie Mountains. Mountains reach 6200 ft elevation in the northwest part of the map, and glacial cirques are preserved on north- and west-facing valleys. South of the highlands and east side of North McQuesten River are plateaus averaging 5000 feet elevation. A major confluence of the North McQuesten River, Eagle Creek, and the East McQuesten River valleys forms a broad and poorly drained, lowland area in the east-central part of the map area.

White spruce (Picea glauca) dominates the active parts of floodplains and black spruce (Picea mariana) colonizes the poorly drained back swamps. Above 3900 feet dwarf birch (Betula glandulosa) and willow (Salix sp.) are dominant.

Dublin Gulch Map Area (106D/4)

Dublin Gulch map area is also dominated by Hyland Group rocks of the Selwyn Basin. The Robert Service Thrust, a Jura-Cretaceous thrust that has emplaced the Hyland Group over Mississippian Keno Hill quartzite, lies along the north part of the map area (Murphy and Héon, 1994) and reenters the area immediately southeast of Lynx Dome (Fig. 1) and extends south across Skate Creek (Green, 1971). Cretaceous quartz monzonite and granodiorite with minor granite and quartz diorite intrusions are exposed at Dublin Gulch and in the headwaters of Lynx Creek.

Dublin Gulch map sheet is dominated by three south-west-trending valleys: Eagle Creek, East McQuesten River, and Lynx Creek (Fig. 1). Eagle Creek empties Steamboat Lake and flows parallel to the southern fringe of the Ogilvie Mountains. Steamboat Mountain at 6000 feet on the north side of the lake, represents the highest peak in the map area. Eagle Creek is separated from the East McQuesten River by Eagle Ridge. The East McQuesten River originates northeast of the map area, and unlike Eagle Creek, maintains its broad valley character across the map sheet until its confluence with the North McQuesten River. South of the East McQuesten River are a series of plateaus that surround the upper Haggart Creek drainage: these are Haggart Dome, Lynx Dome, and the Potato Hills. Lynx Creek valley flows south of the Potato Hills. Haggart Creek and Christie Creek are the only major north-south trending valleys in the map sheet.

Black Spruce (Picea mariana) sphagnum forests are common in the major valleys. Significant stands of white spruce (Picea glauca) line the drainages, including the active and inactive channels on the many alluvial fans. Above 3900 feet elevation dwarf birch (Betula glandulosa) and willow (Salix sp.) are common. Above 4500 feet alpine vegetation is characterized by moss and lichen covering felsenmeer (block fields).

Keno Hill Map Area (105M/14)

Keno Hill map area contains a broad swath of Mississippian Keno Hill quartzite flanked by Devonian Earn Group black phyllite to the north and Yusezyu metasandstone to the south (Murphy & Roots, 1996). The Robert Service Thrust bisects the map sheet from Elsa southeastward through the Gustavus Range. Underlying the Thrust to the north is Keno Hill quartzite and overlying the Thrust to the southwest are rocks of the Yusezyu Formation.

The Keno Hill map area lies between the headwaters of Keno-Ladue River valley and Mayo Lake valley. The broad South McQuesten River valley extends northeastward from near Hansen Lakes in the northwest corner of the map sheet. The Gustavus Range forms the core of the map area with peaks rising to 6700 feet. At least ten cirques are present within the range. The Keystone Creek and Granite Creek valleys split the southern part of the range. The Keno and Galena hills flank the Gustavus Range to the north and west, separated from the range by the Lightning and Duncan Creek valleys. Almost all drainages within the map area have local headwaters originating in these uplands.

White spruce (Picea glauca) forest dominates the lower valleys and dissolves into a subalpine fir (Abies lasiocarpa) community near treeline (4500 feet). Around the Gustavus Range tree-line is approximately 500 feet higher than surrounding regions, likely due to greater annual precipitation from the orographic effect of the mountains on moisture-laden air. Dwarf birch and alpine floral communities pre-dominate above treeline.

GLACIAL HISTORY

The study area was mostly overlain by the pre-Reid and Reid glaciations, and it straddles the McConnell glacial limit. In central Yukon the glaciations were progressively less extensive. The build-up of ice in Yukon consisted of glaciers originating from multiple accumulation zones in the Ogilvie Mountains, Selwyn Mountains, Pelly Mountains, Cassiar Mountains, and St. Elias Mountains. Ice from these centers combined as it flowed toward the central plateau region following the trend of major drainages. Ice from the Selwyn Mountains was largely responsible for glaciating the Stewart Plateau, south of and including the Stewart River valley. Ice from the Ogilvie and Wernecke Mountains glaciated the McQuesten drainage system as well as the Mayo Lake valley. Local montane ice developed in the Gustavus Range, mixing with Cordilleran ice in the valleys of Duncan Creek, Lightning Creek, and Granite Creek during the Reid and pre-Reid glaciations.

Pre-Reid Glaciations

The pre-Reid episode represents multiple undifferentiated glaciations that occurred approximately between 2.5 Ma and 400 Ka.

Landforms resulting from these glaciations have been subsequently eroded and are difficult to identify. In the Mayo area evidence of pre-Reid glaciations is limited to erratics above the Reid glacial limit and to infrequent deposits lying below the Reid glacial sediments in section. For this reason the pre-Reid ice limits were not mapped, although scattered erratics noted in the study area give some idea of the elevation of ice. Pre-Reid diorite erratics were found at 4500 feet on Steamboat Mountain and 4900 feet on Haggart Dome. A possible pre-Reid glacial diamict was noted in the Potato Hills between 4500 and 4600 feet elevation. Pre-Reid erratics were also noted up to 4800 feet on the Potato Hills. Numerous pre-Reid erratics occur noted at 4100 feet in the North McQuesten River map area south of upper Ballard Creek. The upper limit of pre-Reid erratics on Keno Hill is between 5300 and 5400 feet. In the Gustavus Range, pre-Reid ice reached at least 5100 feet, breaching the interfluve between Keystone Creek and Duncan Creek. Potential pre-Reid deposits have been identified in section in upper Duncan Creek and in Haggart Creek.

Pre-Reid glaciations were both higher and extended further west than the later Reid and McConnell glaciations. All major valleys were glaciated during the pre-Reid events and numerous local glaciers developed in cirques above 4400 feet in North McQuesten River map sheet. Ice flow would have been valley controlled with most of the ice originating from the Beaver, Rackla, and Nadaleen River drainages.

Reid Glaciation

The Reid glaciation ended at least 200000 years ago (200Ka) and, according to cold cycles recognized in oxygen isotope ratios from North Pacific deep sea cores, may have begun at least 400 Ka. The 200 Ka date is derived from a date on the Sheep Creek tephra that overlies Reid age glaciofluvial sediments in the Stewart River valley at the Ash Bend section (Berger 1994; Bond 1995). The Reid glaciation followed similar flowlines to pre-Reid glaciations, but was at least 1000 feet thinner in the study area. Reid glacial landforms are better preserved than pre-Reid glacial landforms allowing the mapping of the Reid limit throughout the North McQuesten River and Dublin Gulch map areas (Fig. 2). In the Keno Hill map area the Reid glacial limit is plotted around Galena Hill, on the west side of Keno Hill, in Duncan Creek valley, and sporadically on the north side of Mayo Lake (Fig. 2). Reid glacial limits are less apparent in areas of steeper terrain, such as in cirques of the Gustavus Range and along the south flank of the Ogilvie Mountains in Eagle Creek valley.

Dublin Gulch and North McQuesten River Map Areas

The maximum elevation of Reid ice is 4200 feet in the north east corner of Dublin Gulch map area. From there the ice bifurcated into two valley lobes which advanced along the Eagle Creek and East McQuesten valleys (Fig. 2). At the eastern edge of the North McQuesten River map area the ice had dropped to 3500 feet elevation. The combined valley glaciers of the North McQuesten, Eagle Creek and East McQuesten merged and followed the North McQuesten valley southwestward into the South McQuesten River valley (Fig. 2). The elevation of the ice at the south border of the North McQuesten River map sheet was around 3000 feet. Near McQuesten Lake, eastbound ice crossed a divide into the East McQuesten River at Lime Creek to join the East McQuesten lobe (Fig. 2). Ice from the headwaters of the South McQuesten valley also escaped into the valleys of Lynx Creek and Skate Creek and followed the Haggart Creek drainage to reconverge with ice in the South McQuesten River valley (Fig. 2). Some of this ice lobe split at the confluence of Lynx Creek and Haggart Creek valleys and flowed north into the upper Haggart Creek drainage (Fig. 2). The elevation of the ice reached 3600 feet on the south side of Potato Hills, 3500 feet at Stuttle Gulch (near Dublin Gulch), and 3300 feet at the divide between Ironrust Creek and Christie Creek. Although most of the Haggart Creek drainage was engulfed by the Reid glaciation, the effect of ice in the valley was likely more of deposition than erosion, particularly where mining practices are currently focussed. Because Haggart Creek valley above the junction with Lynx Creek valley is transverse to regional ice flow, the glacier had limited energy to scour and remobilize sediments, resulting in burial of interglacial deposits below a drape of till and outwash. This preservation effect was enhanced by Haggart Dome, Lynx Dome and the Potato Hills which provided a shield against ice converging at the headwaters of Haggart Creek and Dublin Gulch (Fig. 2). Placers in this area owe their existence to this fortunate physiography and proximity to the local glacial limit.

Keno Hill Map Area

In the Keno Hill map area Reid ice completely surrounded the Gustavus Range, Galena Hill, and Keno Hill (Fig. 2). Ice advanced westward, up the Keno-Ladue River toward the Keno area, and southward, up Faith Creek where it probably met local ice emanating from Allen Creek, MacMillan Gulch, and McNeill Gulch. Local ice did not develop at the headwaters of Thunder Gulch during the Reid glaciation. Ice from the MacNeill and MacMillan drainages flowed westward along Lightning Creek to merge with Keno-Ladue ice advancing up Christal Creek valley and continued southward in the Duncan Creek drainage (Fig. 2). The merging of Keno-Ladue ice with a large South McQuesten glacier near lower Christal Creek likely forced Keno-Ladue ice over the Christal Creek divide into the Duncan Creek drainage. Glacial fluvial sediments in the headwaters of the right fork of Thunder Gulch, suggest that Keno-Ladue ice was at least as thick as 4300 feet in this area during the Reid glaciation. Local ice emanated from cirques at the headwater of Upper Duncan Creek and advanced northeast to approximately the mouth of the valley. Ice also advanced into upper Duncan Creek from Duncan Creek valley. Upper Duncan Creek was initially glaciated by local cirque ice and secondly by ice impinging up from the main valley.

The glaciers in the Gustavus Range had a smaller more local source than the ice from the Ogilvie Mountains and were more sensitive to climate change, thus they would respond to both glacial and deglacial climate changes more quickly. When Upper Duncan Creek ice had reached its maximum northwest extent near the con-

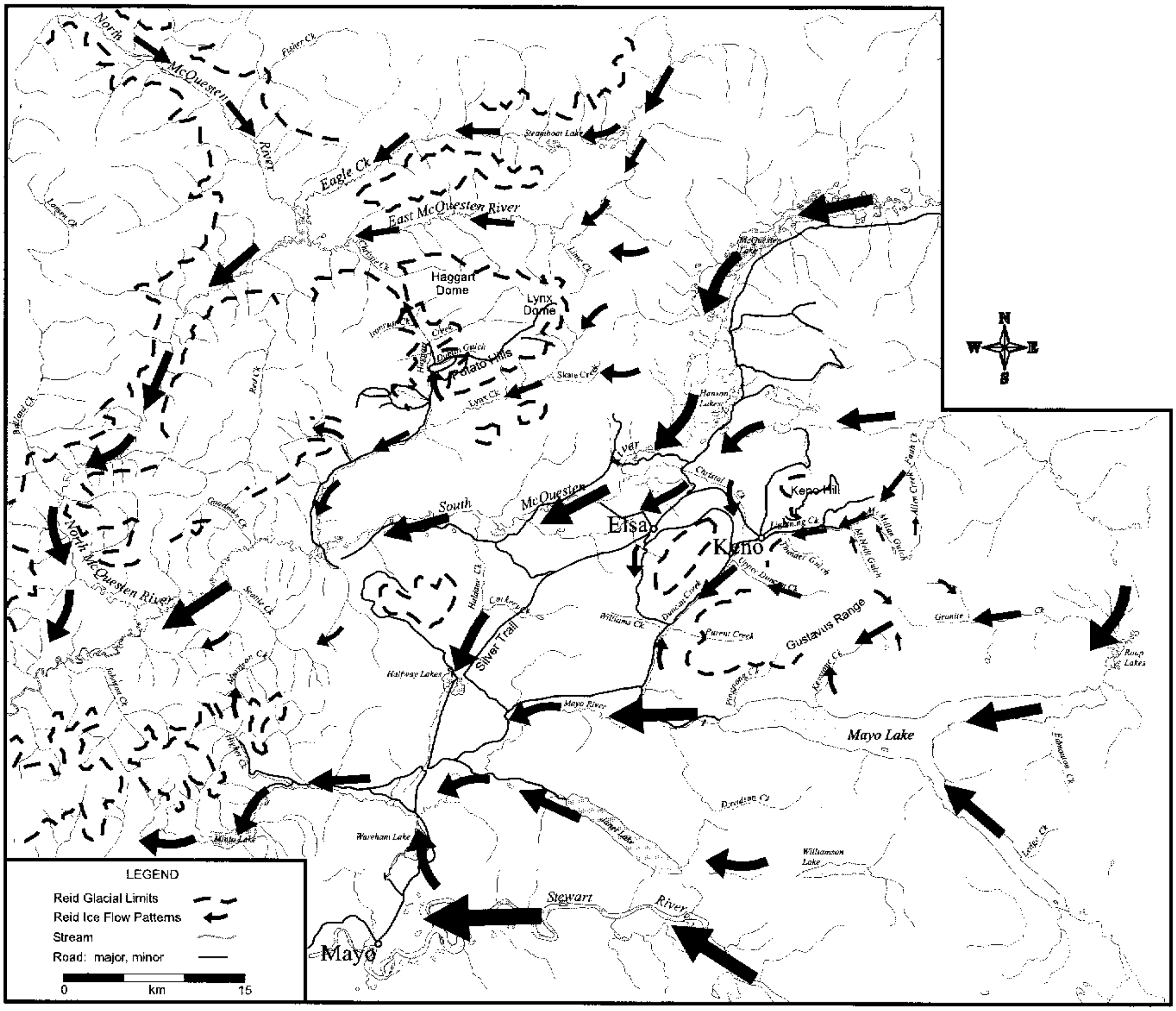

Figure 2. *Reid glacial limit and ice flow-patterns.*

fluence with the main valley, Keno-Ladue ice was only just entering the area and had not yet reached its maximum level. Keno-Ladue ice advanced into upper Duncan Creek after local ice began retreating into the cirques. This timing is demonstrated by overlapping fabrics of two glacial diamicts in upper Duncan Creek. A local montane till was found below a till that contained fabrics suggestive of an up-valley flow (F. Hein, pers., comm., 1996). Similarly ice continuing down the Duncan Creek drainage would have collided with ice advancing up Duncan Creek from the Mayo River valley (Fig. 2). Where the ice lobes met is uncertain but this blockage from the south may have encouraged ice and meltwater to flow into the headwaters of Williams Creek.

Ice advancing into the Mayo Lake region consisted of combined westward ice flow from the Roop (north) and Nelson (south) arms. Ice advancing into the Roop arm originated from the Rackla, Nadaleen, and upper Stewart river valleys, whereas the Nelson arm consisted of ice from the Lansing and Pleasant Creek valleys. On the east side of the Gustavus Range ice from the Roop Lakes area also advanced up the Granite Creek drainage over a divide into the Keystone drainage. It is unclear how far the ice advanced down Keystone Creek. Keystone Creek valley has a more distinct V-shape, compared to the U-shaped configuration of Granite Creek valley, suggesting limited ice movement through the valley. Keystone Creek valley was also occupied by ice flowing up the valley from the mouth. The minimum limit of Reid ice near the mouth of Keystone valley is approximately 4500 feet. The orientation of Keystone valley also suggests a susceptibility to damming during glaciations resulting in the deposition of glaciolacustrine beds.

McConnell Glaciation

The timing of McConnell ice into the study area remains uncertain. The McConnell glaciation had begun by 29.6 Ka according to a C14 date and paleoenvironmental reconstruction from detrital organics below McConnell age till near Mayo; ice free conditions still persisted near Ross River at 26.3 Ka (Matthews et al., 1990; Jackson and Harington, 1991). Dated organic material near Jake's Corner, (south of Whitehorse), suggest McConnell ice had disappeared from the lowlands of southern Yukon by 11.3 Ka (GSC-3831, McNeely, 1991). These dates suggest the McConnell glaciation had 15 Ka to reach a maximum and retreat back to accumulation zones. The timing of Cordilleran ice from the McConnell glaciation in the Mayo area is estimated to be between 17 and 20 Ka.

McConnell glacial landforms are easily recognized in the study area. Glacial limits in the Dublin Gulch and the Keno Hill map areas are shown on Figure 3. McConnell ice did not extend to North McQuesten River map area, although meltwater deposits are present in the valley bottom. Depositional landforms are well preserved in the valley bottoms and sides; particularly in valleys aligned with glacial flow with moderate to gentle valley slopes. Erosional landforms at the McConnell end moraines are particularly striking near Steamboat Lake and in the East McQuesten River valley.

Dublin Gulch and North McQuesten River Map Areas

McConnell ice entering the Dublin Gulch map area originated to the northeast in the Ogilvie Mountains. It traveled down the East McQuesten River, split into the Eagle Creek valley and terminated near the mouth of Lime Creek (Fig. 3). The ice terminated in two lobes, one about 1 km west of Steamboat Lake and the other 2.5 km west of the confluence between the East McQuesten River and Lime Creek (Fig. 3). Flights of former ice marginal channels near the terminus of each lobe suggest the ice stagnated in place (Fig. 4). Stagnation is supported by the plain of hummocky moraine in the valley bottoms and apparent lack of recessional moraines. Moraine deposition in Eagle Creek valley dammed local drainages, leading to development of Steamboat and Eagle lakes.

The South McQuesten ice lobe entered the Dublin Gulch map area at the head of Lynx and Lime creeks. Ice flowed into Lime Creek, terminating above the limit of ice in East McQuesten

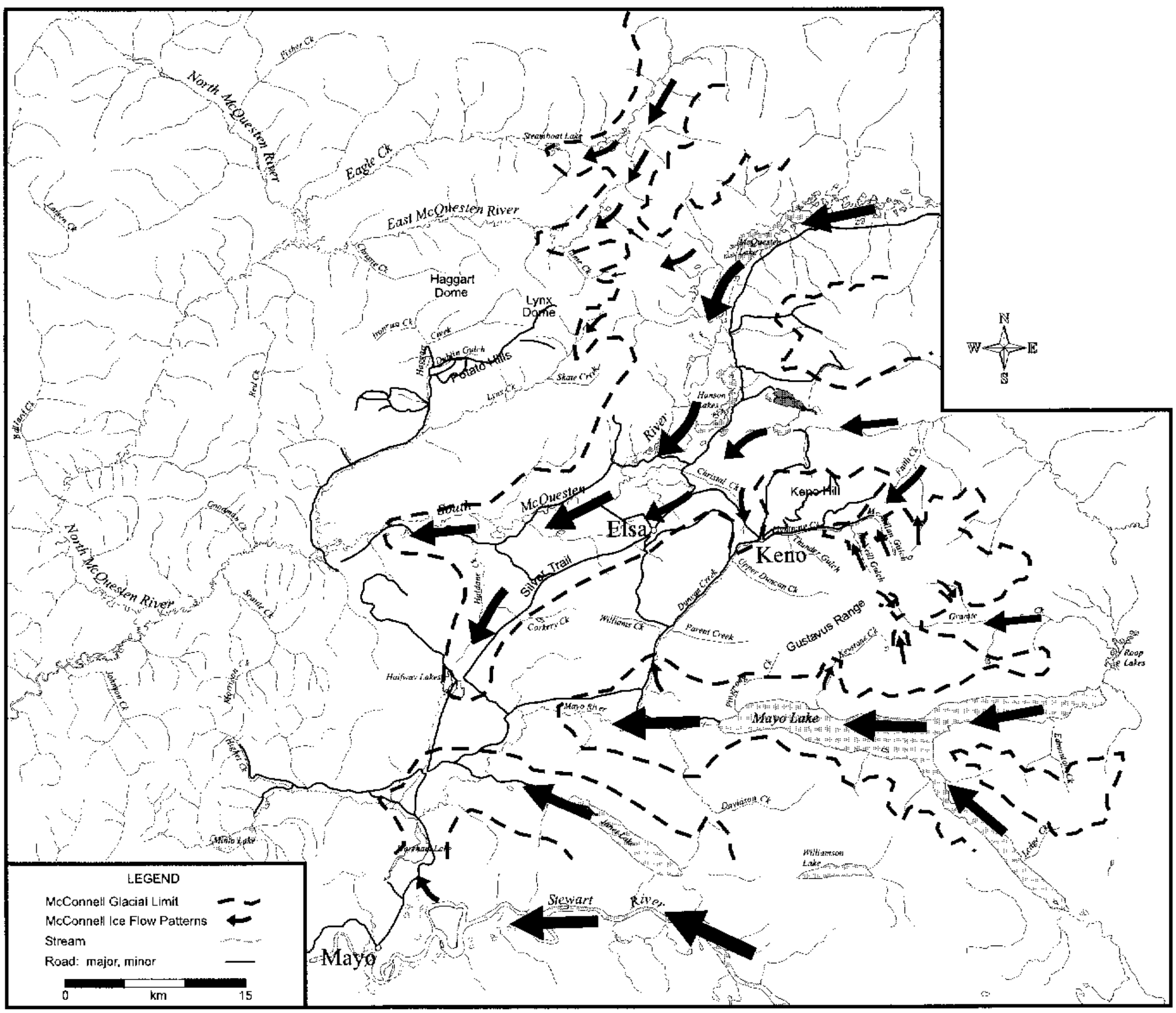

Figure 3. *McConnell glacial limit and ice flow-patterns*

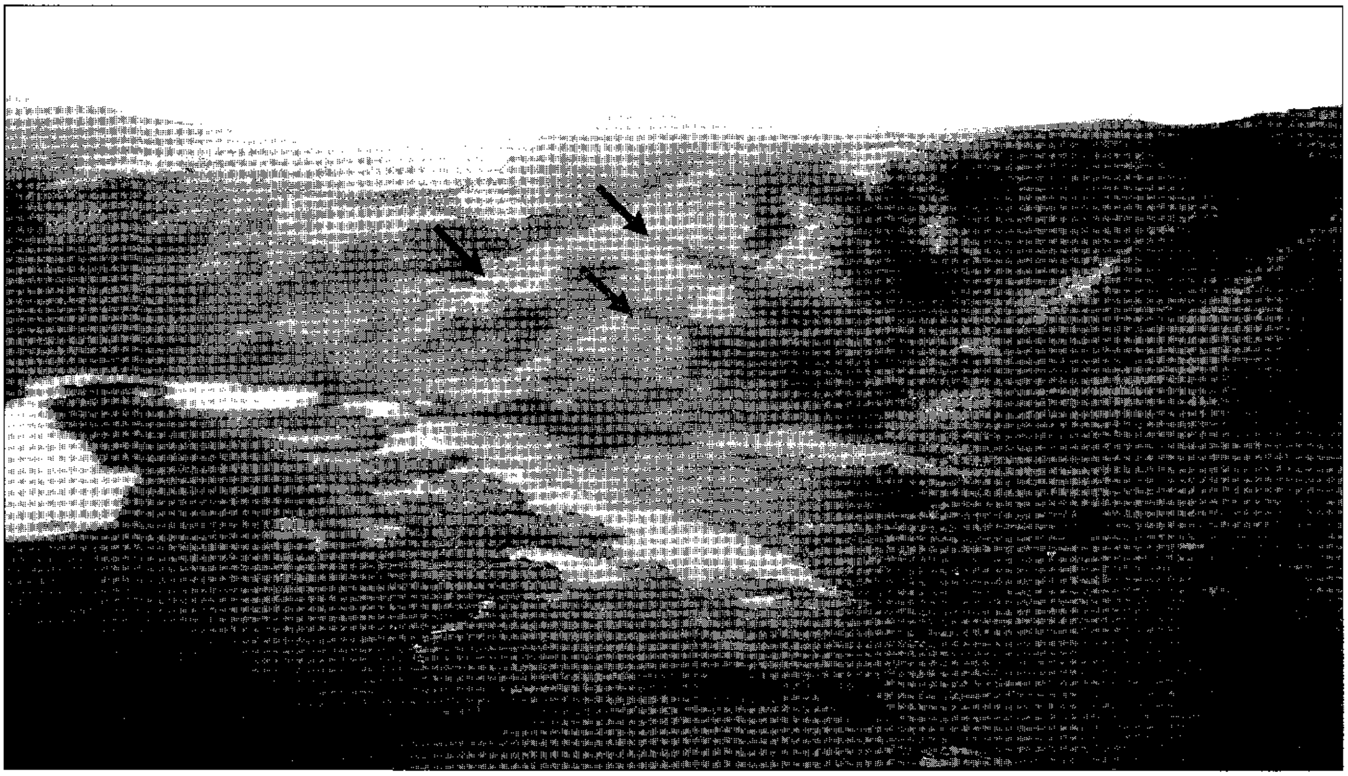

Figure 4. *Flights of former ice marginal channels that were carved during the McConnell glaciation near Steamboat Lake.*

River. South McQuesten ice flowed further into Lynx Creek, terminating approximately 2.0 km upstream from the confluence of Lynx Creek with Skate Creek (Fig. 3).

Keno Hill Map Area

In the Keno Hill map area both Cordilleran ice and local ice were present during the last glaciation. Cordilleran ice advanced westward into the area along valleys now occupied by the Keno-Ladue River, Granite Creek and Mayo Lake. Keno-Ladue ice advanced up Faith Creek and merged with local ice from Allen Creek, McMillan Gulch, and McNeill Gulch (Fig. 3). Ice did not advance down Lightning Creek more than 1 km west of the mouth of McNeill Gulch. Keno-Ladue ice advanced southward over the divide of Christal Creek and terminated immediately south of Keno City at the confluence of Lightning and Duncan creeks (Fig. 3). Bostock wrote that Lightning Creek was part of the McQuesten drainage, evidently discharging by way of Christal Creek, prior to at least one of the glaciations. The age of this diversion is uncertain. Glacial meltwater terraces are present in lower Duncan Creek, resulting from the combined input of meltwater from Lightning Creek, Christal Creek near Keno City, and Upper Duncan Creek. The meltwater benches occur in the canyon above the mouth of upper Duncan Creek, and (partially preserved) at the mouth of Parent Creek. Ice from Mayo Lake valley entered Duncan Creek valley from the south and terminated approximately 2 km south of the mouth of Parent Creek (Fig. 3). Glacial lacustrine sediments identified near the top of a placer section on lower Duncan Creek indicate a glacial lake developed along the margin of the Mayo Lake valley glacier in Duncan Creek (LeBarge, 1996b). A similar process could have occurred during the Reid glaciation; appropriate stratigraphy has not yet been exposed. If it existed, the Reid glacial lake would have been more complex, dams formed by ice flowing south from Keno City and northward from Mayo Lake valley would initially create a lake and subsequently displace it when the lobes merged. A second lake might have formed when the ice lobes retreated. Glacial lake sequences are important depositional environments to recognize, since they may provide a stratigraphic marker relative to potential pre-glacial units. Also, glacial lacustrine sediments may be sufficiently resistant to erosion to resist subsequent interglacial reworking.

Ice advancing into Granite Creek valley from the Roop Lakes area terminated about 5 km west of the divide between Granite Creek and Keystone Creek (Fig. 3). Valley glaciers from upper Granite Creek and the cirque adjacent to the east flank of Mount Albert also terminated at the divide (Fig. 5). A glacial lake was likely impounded at the toe of the Cordilleran ice sheet as it pushed into Granite Creek, but no lacustrine sediments were documented. Glacial meltwater may have drained over the divide into Keystone Creek as indicated by glaciofluvial sediments mixed with fine sand and silt at the divide. The age of these sediments is unclear, however; they may instead be of Reid age. The broad U-shaped character of Granite Creek downstream from the local end moraine in Figure 5, and its proximity to the terminus of the McConnell and Reid glaciations, suggest a surficial deposit of considerable thickness in the valley bottom.

Ice in Mayo Lake valley reached elevations of 3800 feet at Keystone Creek and declined steadily westward. At Davidson Creek the McConnell ice only reached 3000 feet.

Potential Placer Creeks

This section reviews creeks of unknown, but likely placer potential in each of the map areas. Placer potential is based on a number of factors, including geomorphology, glacial history, geochemistry, proximity to existing placers or a lode source, and evidence of previous discoveries. Visits were made for geochemical sampling, geomorphic evaluation, and to check the elevations of glacial limits. Collection of stream sediments for geochemical assays was completed using a 1 mm mesh screen to sieve silt from moss mats and obtain fine-grained bar sediments. The -80 mesh component of each sample was lab analyzed for gold.

New placer creeks are most likely to be found within the Keno Hill map area; with the exception of the Dublin Gulch placer camp only three creeks in the North McQuesten River and Dublin Gulch map areas appear to have placer potential. Low placer potential is mostly the result of unfavorable physiographic trend (east-west and southwest), which overall is generally well aligned with local glacial flow patterns. Although placers may be present in the well-glaciated settings, no examples exist with which to characterize that environment. In the Keno Hill map area a combination of widespread mineralization, known gold occurrences on Mount Hinton and a complex geomorphic setting, provides a number of potential sites for the preservation of placer gold.

North McQuesten River Map Area

Red Creek

Location: Lat. 64° 00′ Long. 136° 08′
NTS 116A/1 and 115P/16

Red Creek is located east of the North McQuesten River, directly south of the confluence of the East McQuesten River (Fig. 1). The upper part of Red Creek flows southward, and turns sharply west for about 10 km before entering the North McQuesten River. The lower east-to-west portion of the drainage parallels regional glacial flow patterns and was actively glaciated during the Reid glaciation. Thick outwash deposits were observed along this portion of the stream. The upper part of Red Creek, however, may have placer potential. Gold-bearing veins are present to the west and the orientation of the drainage is transverse to the main glacial flow, which likely permitted preservation of interglacial gravels from ice erosion. There is a sizeable alluvial plain with a considerable amount of oxide precipitate on stream clasts. Ferricretes (iron-cemented gravel) were observed adjacent to the floodplain, which suggests a lengthy reworking period and no recent dilution of the stream by glacial melt waters. The approach to Red Creek is via the South McQuesten Road as far as upper Goodman Creek where the road deteriorates to an ATV track before the divide into the Red Creek drainage. Much of Red Creek lies within Nacho N'yak Dun settlement lands.

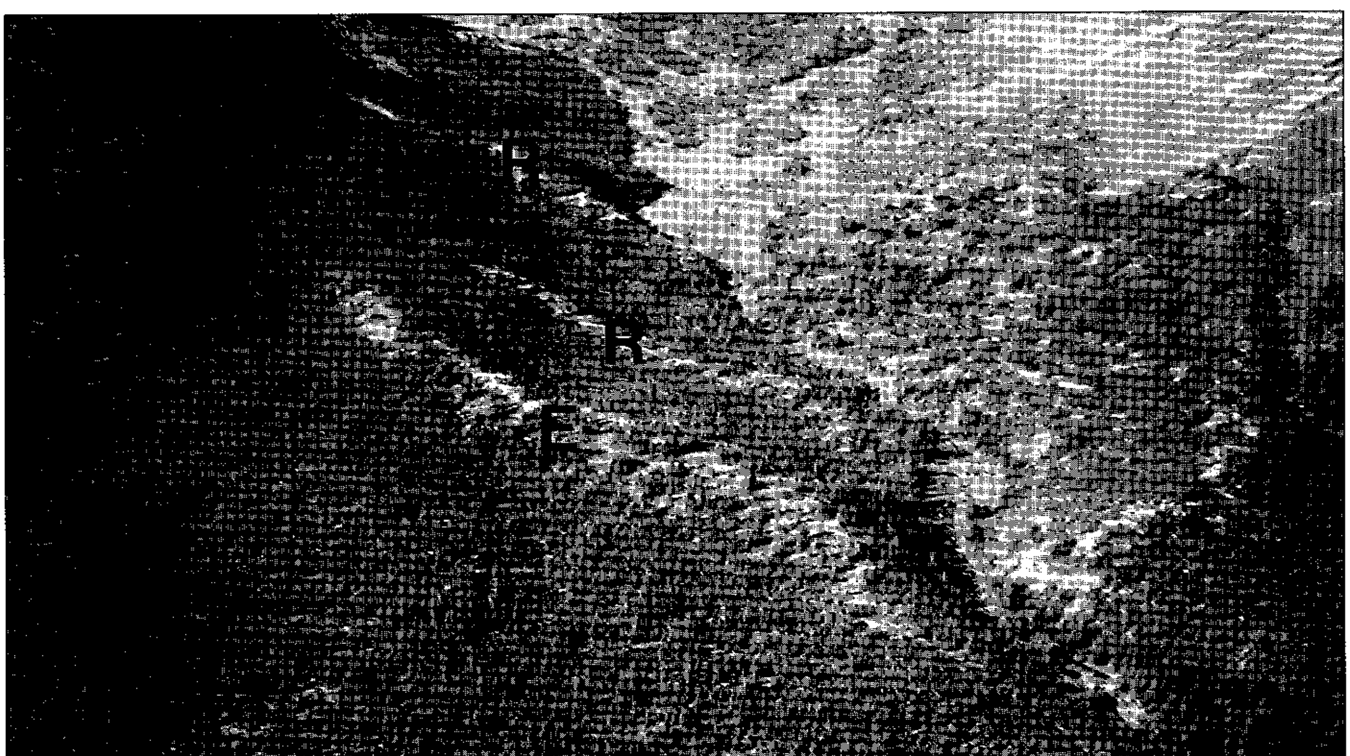

Figure 5. *The Granite Creek end moraine (E) in the Gustavus Range. The moraine was deposited from a local cirque glacier during the McConnell glaciation. Recessional moraines (R) can be seen further up-valley.*

Dublin Gulch Map Area

Lynx Creek Drainage

Location: Lat. 64° 01′ Long. 135° 44′
NTS 106D/4 and 105M/13

Lynx Creek is a tributary of Haggart Creek which flows west-southwest on the south side of the Potato Hills and Lynx Dome (Fig. 1). The upper part of the drainage was influenced by McConnell glaciation and the entire drainage was glaciated during the Reid. (Figs. 2 and 3). Placer potential in Lynx Creek is probably minimal near the surface because of deposition of McConnell outwash, but may be greater below the outwash near bedrock. The depth to bedrock is likely considerable, however, and drilling would be required.

The placer potential and accessibility to placers may be greater in some of the tributaries to Lynx Creek. Several small streams flow southward from the Potato Hills into Lynx Creek. Each of these (the largest being Ray Gulch), has large alluvial fans which developed after the Reid glaciation. The combination of known mineralization in the Potato Hills (Yukon Minfile 106D-026) and moderate stream geochemical results (30 ppb) from a dry creek immediately west of Ray Gulch lend support to a possible gold source within this drainage and some potential for placer gold deposits near the apex of the fans. Access to the fans is best obtained from the unmaintained road along the top of the Potato Hills that descends sharply down the east side of Ray Gulch. A crude winter road or cat track follows the Lynx Creek valley.

Skate Creek

Location: Lat. 64° 01′ 30″ Long. 135° 36′
NTS 106D/4

Skate Creek is a tributary to Lynx Creek on the south side of the valley (Fig. 1), 3 km upstream from Ray Gulch. Skate Creek was last glaciated during the Reid glaciation. An intrusion northeast of Skate Creek and known gold mineralization immediately south of the creek (Len Claims) could provide a bedrock source for possible placer gold in Skate Creek. The lower end of the creek is confined to a canyon containing considerable talus that will hamper exploration. A north-flowing tributary approximately 1 km upstream from the mouth of the canyon, may be the easiest place to determine whether placer gold exists in the bed of the stream.

Keno Hill Map Area

Lightning and Faith Creek drainages

(Lightning Creek, Hope Creek, McNeill Gulch, McMillan Gulch, Faith Creek, and Allen Creek)

Location: Lat. 63°55′ Long. 135° 09′
NTS 105M/14

Lightning and Faith creeks are located on the south side of Keno Hill and capture drainage from Keno Hill to the north and from the Gustavus Range to the south (Figure 1 and 6). All were glaciated during the McConnell glaciation except for Lightning Creek downstream of the McNeill moraine, and Hope Creek (Figure 2 and 3).

Figure 6. *Upper Lightning Creek on the north flank of the Gustavus Range. McNeill and McMillan Gulches are at the right of the photograph. Moraine deposits from McConnell glaciers that terminated near the divide are evident in the middle ground (arrow). The drainage divide in the background connects with Faith Creek.*

Known bedrock gold near Mount Hinton (Yukon Minfile 105M-011, 052, 070 and 073) and placer gold workings in Thunder and Upper Duncan Creeks indicate the likely presence of additional placer deposits. Favorable stream sediment geochemical values from Hope Creek (200 ppb gold), Lightning Creek (120 ppb gold) and McNeill Gulch (65 ppb gold) suggest a gold source in the drainages as well. (Results of samples from McMillan Gulch, Faith Creek, and Allen Creek are forthcoming). Large amounts of glacial fill (end moraine) were deposited at the mouths of McNeill and McMillan gulches and is probably barren (Fig. 6). Potential placer deposits closer to surface will be found upstream of the end moraine in the confines of the glacial valleys or on the alluvial plain that dissects the moraine. Fine gold could be present where the stream has reworked the end moraine sediments.

McMillan Gulch appears to have been diverted from an original northeastward flow into the Faith Creek drainage when Keno-Ladue ice advanced up Faith Creek and blocked the mouth of McMillan Gulch, forcing meltwater and the local drainage to the west into Lightning Creek. If exploration is successful in McMillan Gulch, Faith Creek may also contain placer gold. Similarly, if Faith Creek contains placer gold, then McMillan Gulch is the likely source. Thick glacial deposits should be expected in Faith Creek because of its parallel orientation to McConnell ice flow patterns in the Keno-Ladue valley. Exploration in the cirque valleys of McNeill Gulch, McMillan Gulch, and Allen Creek will likely reveal a surficial layer of colluvial sediments deposited as a talus apron in response to oversteepening of valley walls during McConnell deglaciation. There is good access to these drainages from Keno City via a road paralleling Lightning Creek as far as McMillan Gulch. A cat road at higher elevation reaches the divide above Faith Creek.

Parent Creek

Location: Lat. 63° 50′ Long. 135° 26′
NTS 105M/14

Parent Creek flows west into Duncan Creek, opposite the mouth of Williams Creek (Fig. 1). Parent Creek was last glaciated during the Reid glaciation when ice impinged into Duncan Creek valley from Mayo Lake. Parent Creek was not glaciated during the McConnell glaciation, however outwash was deposited at the mouth from ice at the head of the Duncan Creek valley near Keno City. Although no known gold source is evident in the Parent Creek drainage, anomalous heavy metal values were obtained near its head of the drainage (Boyle et al., 1955), and are comparable to values obtained from Faro Gulch on Keno Hill. Whether anomalous gold concentrations are present is currently uncertain. Some placer mining prospects were carried out in the upper reaches in the mid 1900's (Kreft, 1993), but more recent mining was concentrated near the mouth of the creek.

Geomorphic study of this drainage reveal a distinct layer of glacial sediments lining the valley bottom to the intersection of the 3300 foot contour with the creek. Air-photo interpretation of the elongated mound-like structure in the middle of the valley suggests that it diverted and confined the creek to the south side of the valley where it currently flows along the contact between bedrock and the surficial sediments. The landform coincides with the Reid limit and probably represents a glacial deposit from ice extending up Duncan Creek valley. Fine-grained sediments were also identified at the 3300 foot elevation, and may represent a glacial lake at the margin of Reid ice when upper Parent Creek was blocked. These geomorphic characteristics support the presence of a buried pre-Reid alluvial floodplain. The orientation of Parent Creek, transverse to ice flow in Duncan Creek, meant that ice advancing up Parent Creek likely did not scour the drainage but rather draped it with sediments.

In the past decade, placer mining at the mouth of the Parent Creek valley appears to have been concentrated within the McConnell or Reid outwash terrace parallel to Duncan Creek. Virtually no gravels originating from Parent Creek are present there unless a buried channel was encountered. The outwash nature would certainly lead to poor gold grade, a possible reason for abandonment of mining in this drainage. Previous exploration near the mid-section of the drainage may have sampled only the glacial sediments in the valley bottom. To retrieve an accurate picture of the placer gold potential this surface layer must be removed. The anomalous location of the Parent Creek floodplain suggests little or no reworking of glacial sediments and therefore an intact stratigraphy should be present in the middle of the valley. Further exploration should clarify the high concentration of heavy metals (Boyle et al., 1955) in the upper tributaries and test the stratigraphy in the middle of the valley between the 3000 and 3100 foot contours.

Granite Creek

Location: Lat. 63° 51′ Long. 135° 04′
NTS 105M/14 and 105M/15

Granite Creek, draining eastward form the Gustavus Range (Fig.1) may be considered in two parts; upper Granite Creek and lower Granite Creek. The upper Granite Creek drainage is contained within a cirque valley on the east side of Mount Hinton. Lower Granite Creek is contained within the main valley flowing east into the Roop Lakes. All but the uppermost part of lower Granite Creek was left unglaciated during the McConnell glaciation (Fig. 3). The small portion of the drainage near the confluence of the cirque valley with the main valley that escaped actual glaciation, was however, undoubtedly buried by glaciofluvial sediments. Local ice in upper Granite Creek advanced to the mouth of the cirque valley where a distinct end moraine was deposited (Fig. 5) with a series of recession moraines behind it. Cordilleran ice advanced up lower Granite Creek from Roop Lakes to within 2 km of the upper Granite Creek moraine. Lower Granite Creek flows within a broad u-shaped valley that has been heavily glaciated during all periods of glaciation. Although depth to bedrock in lower Granite Creek is uncertain, a considerable amount of glacial drift is normally associated with end moraine areas, potentially eliminating lower Granite Creek from small-scale placer mining.

Upper Granite Creek and the area inside the local ice limit, including the area between the local end moraine and the Cordilleran moraine, may be more prospective. Bedrock gold occurrences around Mount Hinton indicate a possible lode source for placers in the drainage. This is supported by a slightly anomalous gold geochemical value of 20 ppb obtained from stream sediments near the local end moraine. At least 20 m of moraine overburden containing large cobbles and boulders was observed in the valley bottom in this area. The floodplain between the moraines, however, is broad enough in some sections that it should be prospected for potential placers reconcentrated out of the moraine.

A secondary channel of upper Granite Creek should also be investigated. From air photographs a channel was identified approximately 400 m east of Granite Creek immediately downstream from the local ice limit in upper Granite Creek. It is uncertain whether the channel represents an abandoned pre-McConnell interglacial floodplain or a temporary channel created from meltwater emitted from the toe of the McConnell glacier.

Access to Granite Creek is via a cat road along Keystone Creek from Mayo Lake which in 1996 was suitable for ATV travel.

Corkery Creek

Location: Lat. 63° 52′ Long. 135° 37′
NTS 105M/13

Corkery Creek is located in map sheet 105M/13, west of Keno Hill map area, and is part of the Haldane Creek drainage at the south end of Galena Hill (Figure 1). Corkery Creek shares its headwaters with Williams Creek, which flows east into the Duncan Creek drainage. The upper part of the drainage is of interest. A bush road leaves the Silver Trail highway approximately 9 km northeast of Halfway Lakes Lodge to access the upper part of the drainage.

Corkery Creek was entirely glaciated during the Reid glaciation (Fig. 2), but McConnell ice was not thick enough to glaciate the upper region of Corkery Creek (Fig. 3). Large outwash terraces near the head of Williams Creek and the flat bottomed morphology of upper Corkery Creek suggest that meltwater also escaped into the Corkery Creek drainage during Reid deglaciation. At its mid-point, Corkery Creek appears to have been diverted from its original drainage during the McConnell glaciation because it opens into a broad flat area approximately 2 km east of the Silver Trail Highway. Downstream of the flat expanse Corkery Creek makes a final drop into Haldane Creek valley, across the Silver Trail highway. The diversion of Corkery Creek occurred when McConnell ice, positioned in Haldane Creek valley, forced meltwater to flow along the ice margin to drain further south. This interpretation is supported by the under-developed appearance of the channel in the lower half of the creek. Also, Corkery Creek, where it flows adjacent to the moraine, approximately follows the contour, a morphology indicative of glacial diversions. The location of the original drainage was likely closer to the Corkery Creek access trail, in a more direct line toward the Haldane Creek valley.

Potential placer deposits in Corkery Creek may lie near the head of the drainage or in a paleo-lower channel. A stream sediment sample from the north tributary channel measured 55 ppb gold and 1190 ppm arsenopyrite. The arsenopyrite value was the highest of its kind obtained from any drainage in the study area during the 1996 field season. These results support the presence of a lode source but evidence for placer gold is lacking.

Exploratory work will be hampered by the high water table in this valley. Most of the upper part of Corkey Creek is poorly drained because the low gradient and fine grained silts and sands that induce a perched water table. Only a few pockets of fluvial gravels are exposed in the upper part of the basin. Exploration drilling should penetrate the surface layer of fine grained sediments to test underlying gravels for gold placers. The origin of the surface fine-grained sediments may be related to the McConnell glaciation. Corkery Creek appears to have an anomalously shallow drainage above the McConnell limit. It is probable that damming, caused by McConnell ice and its lateral moraine, has resulted in a temporary mid-drainage base level change on Corkery Creek, thus causing the stream to aggrade. The decreased gradient of stream flow led to an accumulation of fine grained sediments that normally would be transported in suspension out of the drainage. Gravels underlying the fines are likely from the pre-McConnell interglacial period.

Keystone Creek

Location: Lat. 63° 48′ Long. 135° 11′
NTS 105M/14

Keystone Creek (Figs. 1 and 7) is one of the larger drainages that empties southward into Mayo Lake. Access to Keystone Creek is available along a well-maintained road along the north shore of the Lake to the Brinkerhof property.

During the McConnell glaciation the lower half of Keystone Creek was glaciated by ice impinging in from Mayo Lake (Fig. 3). Keystone valley is oriented transverse to westward ice flow, thus limiting erosion of previous fluvial deposits in the drainage. The distinct V-shaped morphology of the drainage supports this interpretation. Meltwater surmounting the divide from Granite Creek probably augmented the drainage. The orientation of the valley likely caused a glacial lake to form with outlets marginal to the ice along the north side of the Mayo Lake valley. Although the lake was not large, it may have trapped a sizeable amount of fine-grained sediment in the drainage.

Gold in Keystone Creek is possible because it drains the same area of gold veins tapped by Upper Duncan Creek. In Upper Duncan Creek however, local cirque glaciers may have initially excavated the gold. A large, post-McConnell alluvial fan complex developed at the outlet of Keystone Creek into Mayo Lake (Fig. 7). The perched meltwater channel likely contains resedimented glacial material, however, should be tested for redistributed placer gold. Two perched fan remnants are preserved on either side of the apex of the active fan (Fig. 7). Although bulldozer testing of the alluvial sediments near the apex of the fan is evident, these gravels may not be derived from the head of Keystone Creek, and instead consist of resedimented glacial till and outwash.

Edmonton Creek

Location: Lat. 62° 46′ Long. 134° 44′
NTS 105M/15 and 105M/10

Edmonton Creek flows north into the Roop (north) arm of Mayo Lake (Fig. 1) and requires boat access. A trail leads to the apex of the fan and the abandoned discovery claim.

Edmonton Creek was almost entirely glaciated and only the upper reaches of the drainage escaped the McConnell ice (Fig. 3). The transverse orientation of Edmonton Creek, relative to regional ice flow, suggests that glacial sedimentation predominated and there is a high probability of an intact buried fluvial gravel.

Gold may be present because Edmonton Creek eroded the same metasedimentry and metadiorite units as gold-bearing Ledge Creek, located on the opposite side of the plateau (Fig. 1). A stream sediment sample from the apex of the fan on Edmonton Creek yielded 80 ppb gold, favorable support for a potential lode source in the drainage, although, glacial contamination is possible. Earlier mining led to encouraging results (Kreft, 1993) but modern mining has not been attempted. Large boulders and the narrow canyon above the alluvial fan may hinder exploration.

Upper Davidson Creek

Location: Lat. 63° 43′ Long. 135° 25′
NTS 105M/11 and 105M/14

Davidson Creek drains northwest from the plateau between Mayo Lake and Williamson Lake. A road provides access to Davidson Creek at points upstream and downstream of the lowermost canyon. Mining has concentrated in the canyon and at the mouth of the canyon where the stream enters the thick fill of the Mayo River valley. Work has been sporadic on Davidson Creek because the gold distribution is erratic (Kreft, 1993), but large-scale mining of low benches and bedrock is advancing up the canyon.

The lower third of Davidson Creek lies within the McConnell glacial limit (Fig. 3) and the valley morphology is a result of a glacial diversion above the canyon. Prior to the last glaciation upper Davidson Creek flowed south to Janet Lake (Fig. 8-1). Lower Davidson Creek at this time had a more local drainage and the canyon was likely less developed or absent. When McConnell ice in Janet Lake valley reached its maximum extent meltwater was diverted over the low divide northward into the Mayo River valley (Fig. 8-2). More rapid erosion formed a canyon and ensured the northward course (Fig. 8-3). Glacial outwash outlines upper Davidson Creek near the diversion (Fig. 8-4).

Placer gold may be present in upper Davidson Creek. The origin of gold in the canyon of lower Davidson Creek is unknown, although, its flattened morphology suggests that it is moderately traveled (Kreft, 1993). If placer gold is found near the point of diversion, just inside the canyon (meltwater channel) this would suggest an upstream source. Placer gold deposits do not normally originate in meltwater channels that were not previously occupied by an interglacial stream. If the gold originated in the headwaters of Davidson Creek, as current geomorphology suggests, then a large part of this drainage warrants exploration. Backhoe trench-

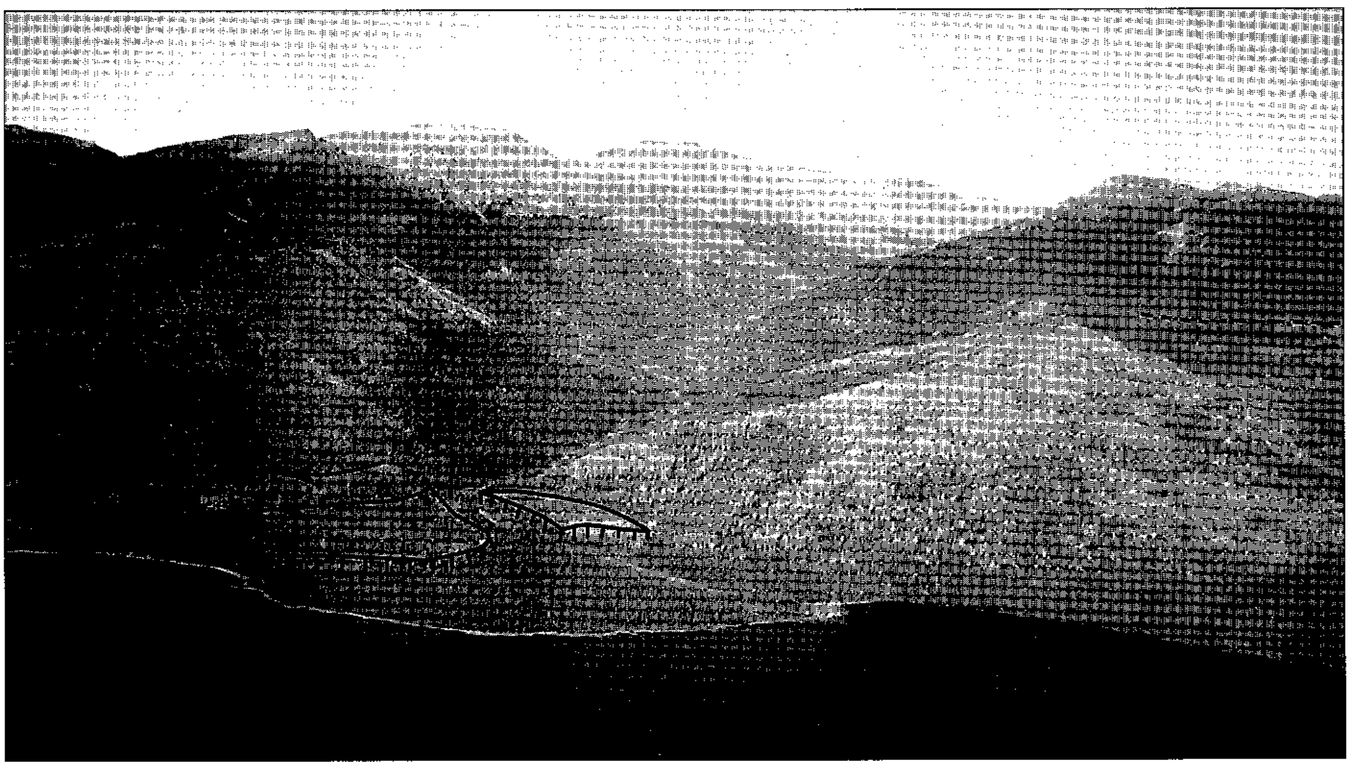

__Figure__ 7. Keystone Creek and its fan/delta built into Mayo Lake. The dashed lines are the McConnell ice limit in Mayo Lake valley. The paleo-fans are outlined on either side of the modern alluvial fan/delta. The perched meltwater channel of McConnell-age Keystone Creek is marked by the arrows.

ing was noted near the diversion point. The glacial fluvial outwash gravels there could have been mistaken for interglacial fluvial gravels by miners unfamiliar with the stratigraphy. The broad outwash plain near the head of the canyon was created by meltwater from the impinging Janet Lake ice lobe. Further prospecting should attempt to identify a more locally derived gravel below the glacial outwash if it escaped McConnell erosion. If found, this paleochannel representing upper Davidson Creek prior to the McConnell diversion should extend southward toward Janet Lake.

CONCLUSIONS

The glacial history of the study area (116A/1, 106D/4, and 105M/14) is characterized by progressively less extensive glaciations. The oldest pre-Reid glaciations were the most extensive and glaciated the entire area leaving small nunataks in the Ogilvie Mountains and Gustavus Range. Deposits from the pre-Reid glaciations are limited to the subsurface and to infrequent erratics above the Reid glacial limit. The Reid glaciation was much less extensive, but still glaciated all valleys to an average of 4500 feet in the eastern part of the study area and 3000 feet on the western boundary. Deposits from the Reid glaciation are common above and westward beyond the McConnell glacial limit and in the subsurface of mining exposures. Numerous lobes from the McConnell glaciation terminated in major valleys of the study area. McConnell sediments comprise a well- defined layer in all valleys affected by this glaciation. Most of the main valleys, whether glaciated or unglaciated by the McConnell event, are lined with broad outwash plains deposited at the end of the glaciation approximately 15,000 years ago.

The application of glacial history, geomorphology, geochemistry, regional setting characteristics, and historic records were used to identify prospective placer creeks in the study area. These investigations suggest numerous prospects in the Keno Hill-Mayo Lake area and three drainages in the Dublin Gulch and North McQuesten River map areas. The complex physiography of the Keno Hill area created a number of moderate-sized valleys with diverse geomorphic attributes. The orientation and location of these drainages proximal to the terminus of recent, less extensive,

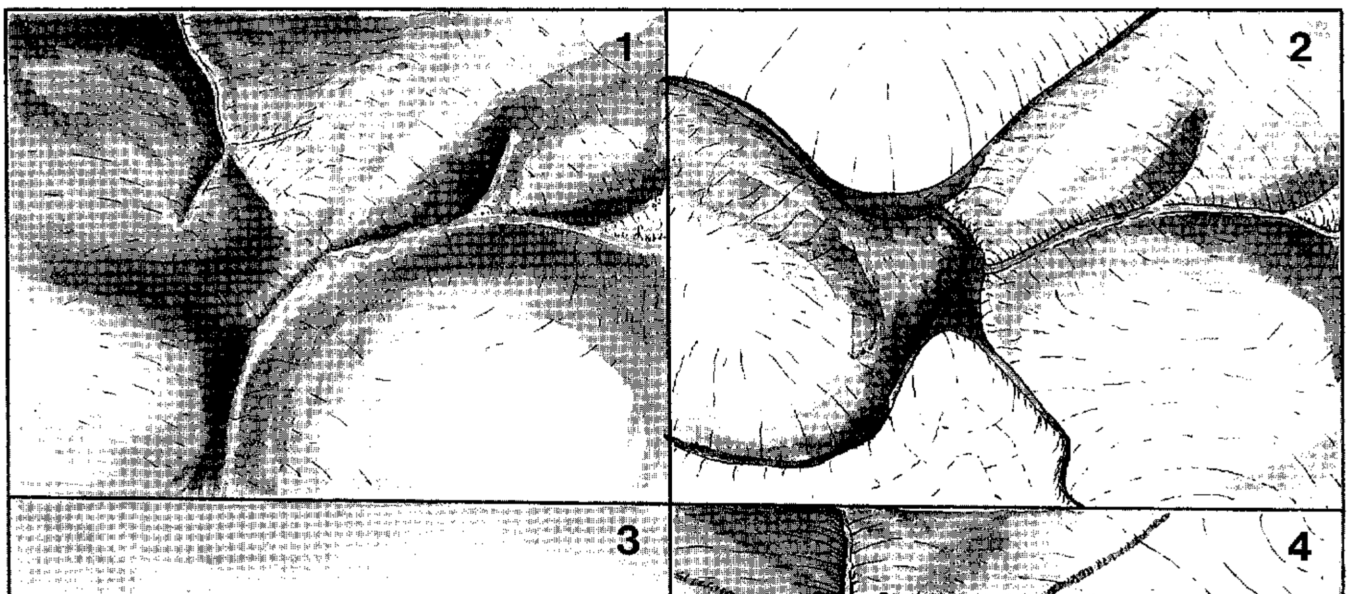

Figure 8. *A sequence of drawings recreating the diversion of Davidson Creek during the McConnell glaciation. Drawing 1 illustrates a proposed pre-McConnell drainage. Drawing 2 illustrates how the McConnell valley glacier in Janet Lake valley blocked the drainage from the south and diverted it over a pass into the Mayo River drainage. Drawings 3 and 4 show the drainage today. Note the canyon cut during the diversion.*

glaciations allowed many of them to escape direct glaciation. Active glacial erosion in local cirque valleys in the Gustavus Range may have actually enhanced the input of lode gold into the post-glacial fluvial regime. With deeper excavation or drilling, opportunities for locating and developing new gold placers in the Keno Hill - Mayo Lake area are good. In the Dublin Gulch and North McQuesten River map areas few valleys escaped active glacial erosion and sedimentation during the Reid glaciation. Isolated placer deposits may be present but prospecting should focus in areas marginal to traditional camps.

ACKNOWLEDGMENTS

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So You Want To Go Mining in the Yukon, Eh?

Leo P. van Kalsbeek [1]

VAN KALSBEEK, L.P. 1997. So You Want To Go Mining in the Yukon Eh?, In: LeBarge, W.P. and Roots, C.F. (editors.), 1997. Yukon Quaternary Geology Volume 2, Exploration and Geological Services Division, Northern Affairs Program, Yukon Region, p.44-50

ABSTRACT

Many people who want to get started placer mining in the Yukon have questions about many things including cost, types of equipment, government regulations, and of course, "Where is the gold?". The capital cost of equipment may be the determining factor and will vary according to the size of the operation. Research and geology are important, and drill results can prove valuable. Access, whether via river, winter road, air or all-season road is an important consideration. It is also crucial to have the right equipment for the job of mining and washing the gravel. Finally, being able to meet the effluent standards for water use is a vital consideration for an ongoing, successful mining operation.

RÉSUMÉ

Plusieurs personnes qui veulent se lancer dans l'exploitation de placers au Yukon se posent diverses questions concernant notamment les coûts, le type d'équipement et la réglementation gouvernementale. Elles se demandent aussi, bien entendu, « Où est l'or ? » Les frais d'investissement pour l'équipement, qui varient selon la taille de l'exploitation, peuvent représenter le facteur déterminant. La recherche et les données géologiques sont des facteurs importants et les résultats de forage peuvent s'avérer utiles. L'accessibilité, que ce soit par rivière, route hivernale, air ou route toute saison, constitue une autre donnée importante. Il est en outre essentiel de disposer de l'équipement approprié aux travaux d'exploitation minière et au lavage du gravier. Enfin, la capacité de satisfaire aux normes sur le rejet des eaux usées est un facteur d'importance vitale pour une exploitation minière durable et réussie.

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***Figure 1**. Stripping of bench overburden. Modern creek has incised bench gravels, Steve Johnson, Upper Burwash Creek.*

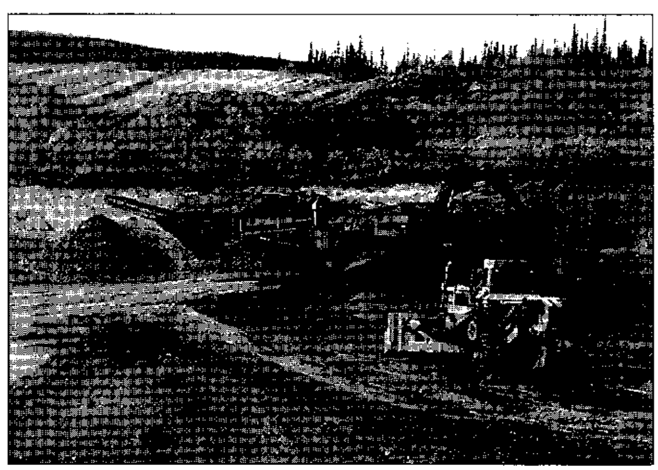

***Figure 2**. Caterpillar D-10N bulldozer pushing up pay gravels to a Hitachi excavator that is feeding gravel to a 5-foot diameter trommel, Newcan Placers, Quartz Creek.*

The Beginning

Invariably people ask me the same questions about mining. "How much money do I need?" "What's the right kind of equipment to buy?" "How do I network with other miners?" "Where can I get mining claims and how much will they cost me to buy?" "Where is the gold, in the valley bottom or on the bench and how do I get started?" "Where do I get information regarding the many government Acts and regulations?"

These questions and many more like them are valid and should be asked before entering into the mining game (crying game). Before you get started, however, consider the following:

Capital

"How much is it going to cost?"

This may be the determining factor for most people, and the cost can vary depending on the size of your operation. Which leads us back to the question of your investment. It's the single most important element. Being under capitalized can be the death of any enterprise. To be able to weather the storm of bad luck, like a mechanical failure or no water, is of prime importance. Also, the ability to move to another location if the grades are not good enough!

Typical Placer Creek

For this example let's keep the project small. Start with a one-or two-person operation. What are you going to need with respect to equipment and supplies? Well, this will depend on the type of ground. Is it a wide or narrow valley? How deep is it to bedrock? Is there thirty to 40 feet of overburden, and is it frozen? If so, my advice is to go somewhere else, because deep ground can kill a new and inexperienced small operator. "Is there any evidence of old workings, and has the ground been mined out? Are the claims worth the selling price? What's the cost per claim? Is the royalty too high and the gold price too low? Does the vendor want an advance on royalties? What's the purity of the gold? What type of stream is it with regards to fish habitat?" The answers are there; you just have to do your homework!

Try to obtain drill reports (if any) at archives in Ottawa, aerial photos, old geological reports, and surficial maps. Walk the ground and look for evidence of old workings. If you feel that the creek has potential, hire a geologist to do some geophysical work. Once you understand the bedrock profile, spend the money to have the property drilled. This is far better than the common practice of, "Let's mine it and see what we get."

Bench Gravels

"What makes bench gravels so appealing?"

It all started back in 1897 when gold was discovered in the white channel benches of the Klondike. When the hordes of new arrivals came to seek their fortunes on Bonanza Creek, they found all the creek claims staked, which started exploration in the hills and surrounding creeks. Benches in the Dawson Mining District have been worked by shafting, drifting and hydraulic mining methods.

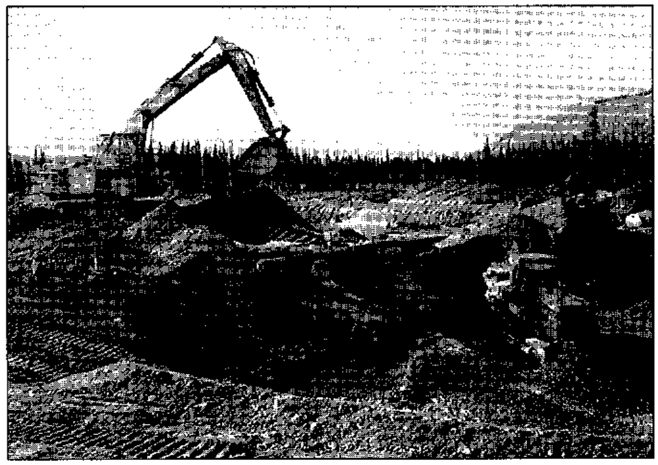

Figure 3*. Three-run box operating on Indian River, Kodiak Gold Corporation.*

Geologists today have discovered different types of bench deposits in the Yukon. This new information is a great benefit to the mining industry. As creek deposits diminish in the Dawson Mining District, miners are starting to raise their heads to the hills, as these potential deposits begin to attract more attention.

Two types of bench deposits located in the Yukon are glaciofluvial and alluvial. Glaciofluvial gravels are located along rivers that have been glaciated. The depth to bedrock is very deep in most cases, and the ancient river beds have been scoured and are usually not a workable resource. It is critical however to ascertain the ice limit of former glaciation. This evidence can tell us whether we are dealing with a glaciofluvial deposit, or where an alluvial bench deposit ends or begins. This can be determined from maps of surficial geology.

If the property has been unglaciated and it has been determined that the deposit is alluvial, it is generally regarded to be a more viable resource. River tributaries have a higher probability of unglaciated alluvial gravels that are usually a shallower and richer deposit. Along with lower overburden, the shallower depth to bedrock makes evaluating these deposits more attractive.

Because bench mining does not affect stream beds in most cases, there is less concern about environmental impacts.

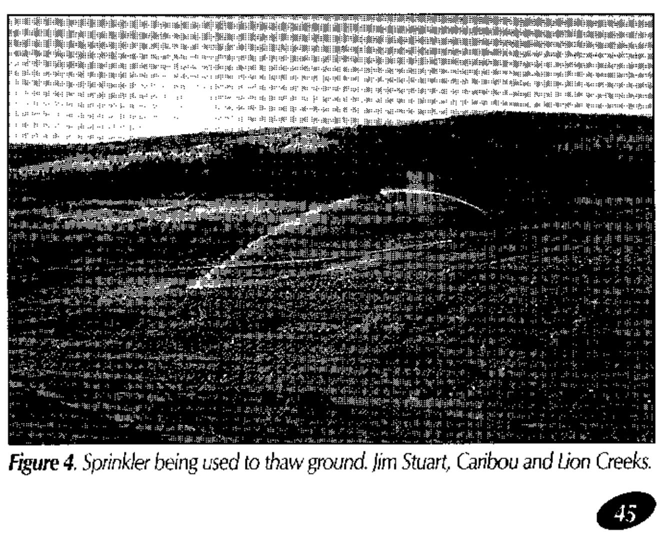

Figure 4*. Sprinkler being used to thaw ground. Jim Stuart, Caribou and Lion Creeks.*

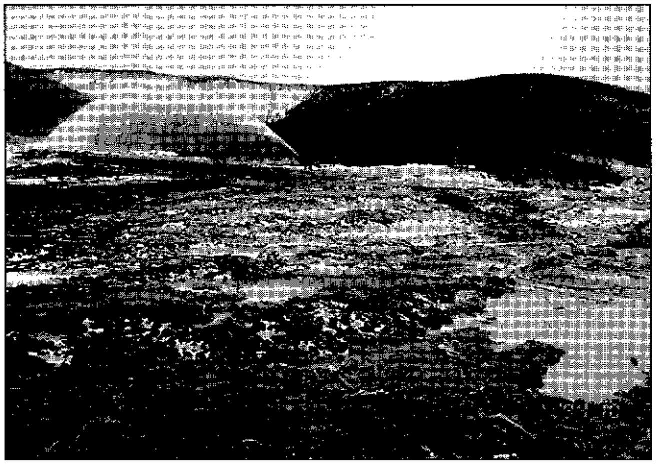

Figure 5. Monitor washing of black muck on left limit bench on Thistle Creek. Stuart Schmidt operation.

ACCESS
"SHOULD I TAKE THE HIGH ROAD OR NO ROAD?"

Fly in, barging or driving? Access to a mining operation could be a logistical nightmare and should be given serious consideration. Ask any placer miner which of the above he or she would pick and it's the road every time. The reasons are simple; barging fuel from Minto Landing to Canadian Creek, for example, is expensive. Load size varies depending on how high or low the river is. If the river is too low, freight must be barged from Dawson City. This costs more because it's a longer distance, and upstream all the way.

Transport the bulk of your fuel or equipment in the peak flow periods which is generally in the first two weeks of June.

Flying into remote areas is even more expensive. The bulk of your fuel, equipment and camp must be brought in by winter road (don't forget the land use permit). Aircraft charters in summer months can be used for delivery of parts, fuel, food and crew changes. All this expense adds up quickly and should be considered in your business plan.

So what are some ups and downs of hard-to-access property? You may find larger tracts of ground that will sustain the approximately 50% increase in overall transportation cost. Have equipment in good order, because break downs will affect production.

For the new miner, access by all-weather road is highly recommended. You'll still have to haul fuel and equipment in by tractor-trailer, but the costs involved are far less than the alternatives.

THE RIGHT EQUIPMENT

Now that we have dealt lightly with claims on creeks and benches, it's time to decide on the right equipment. I suggest getting your hands on the 1991-92 Yukon Placer Mining Industry report, which contains an excellent article entitled "The Right Machine for the Job", which will help you decide on the type of equipment required.

If you're mining in the Yukon, most miners will tell you that trying to mine in a permafrost zone is a tough go without a bulldozer. You're going to need a bulldozer with a u-blade and ripper. What size you purchase will depend on your pocketbook. A D9 Caterpillar or 355 Komatsu equivalent dozer would be the optimum machine size because of their ability to strip frozen black muck, move yardage, and push tailings. Smaller models will take a lot longer and shake the operator's fillings loose.

Now, what's feeding the sluice plant and how is the material getting there? I recommend a 20-ton hoe to feed the sluice plant. You will be hard pressed to find another machine that can perform as many different functions–such as digging drains, constructing settling ponds, stripping overburden, feeding the plant, digging testing pits and moving the plant–at such low costs. Remember: hydraulics are cheap.

WATER USE

Any water use for placer mining requires a water licence that includes a fish habitat compensation / restoration plan. Since mining waste water influences a stream channel, you must treat all effluent by way of settling ponds.

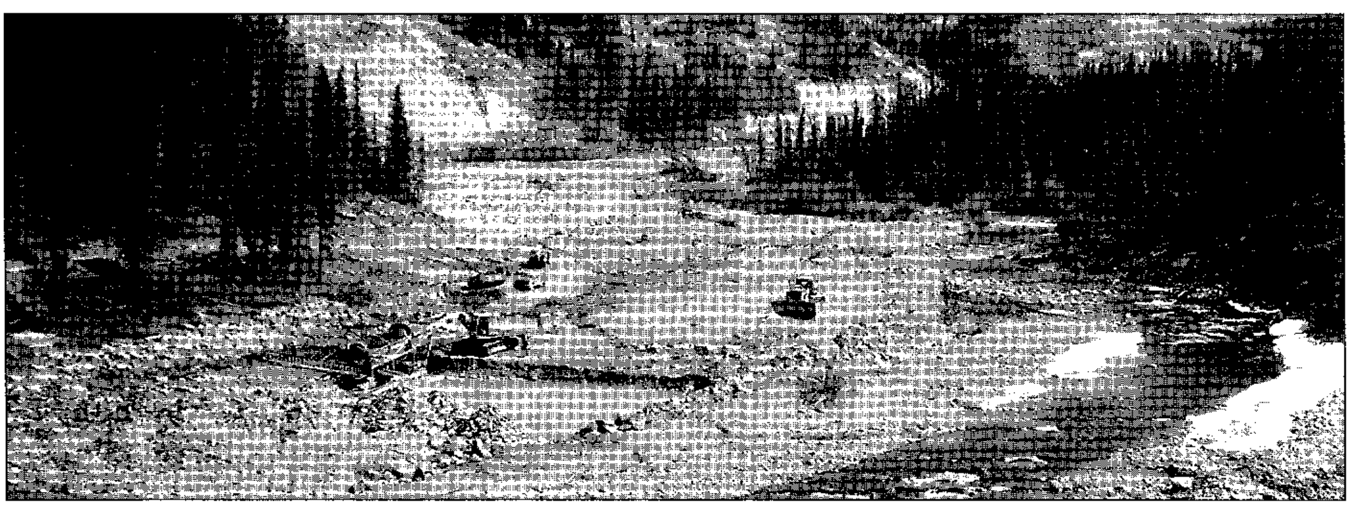

Figure 6. Looking upstream at floating trommel wash plant in an abandoned secondary channel in the more protective side of a gravel point bar. Al Dendys, Gladstone Creek.

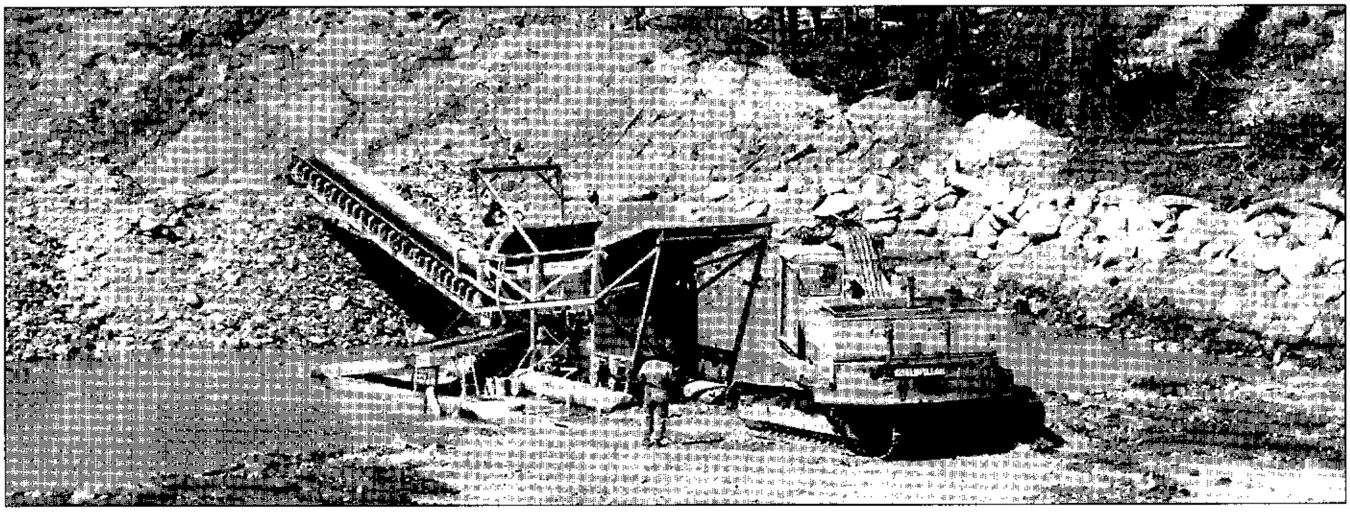

***Figure** 7. Close up view of hoe and floating trommel wash plant operation. Al Dendys, Gladstone Creek.*

Some probable examples of water use are: sluicing pay material; thawing frozen ground; hydraulic stripping; draining the mining cut; and altering or diverting a flow of water in any way.

If you're not sure what constitutes a water use, contact a mining inspector or the Yukon Territory Water Board.

Wash Plants

"What kind of wash plant is the right one?"

The two most popular plants in the Yukon today are trommels and shaker wash plants. The cost difference between the two could be as much as 50,000 dollars, the latter being the cheapest. They should process a minimum of 100 yd3 per hour, because volume is the key if you find yourself in material that is not high grade. Processing the material as efficiently as possible will keep an average grade value (evening out the highs and lows).

Keep production and classification (sorting gravel by size) in mind before you buy or build your first plant. This is fundamental to keeping the "gold in the box". The more you classify the less water you use, which results in a better recovery, and will extend the life of your settling ponds. Of course classifying has certain draw backs. The less water you use the cleaner it should be to avoid plugging of spray nozzles and hydraulic riffles. This can be overcome by building filter systems that can easily be cleaned out, both on the plant and at your pump pond. Clean water is preferred and not having to recycle is best, although this is not always possible.

Portability is important, to keep the effort of moving a wash plant to a minimum.

You want to be able to move the wash plant efficiently and quickly. Remember, "that it is easer to move Mohammed to the mountain than the mountain to Mohammed"!

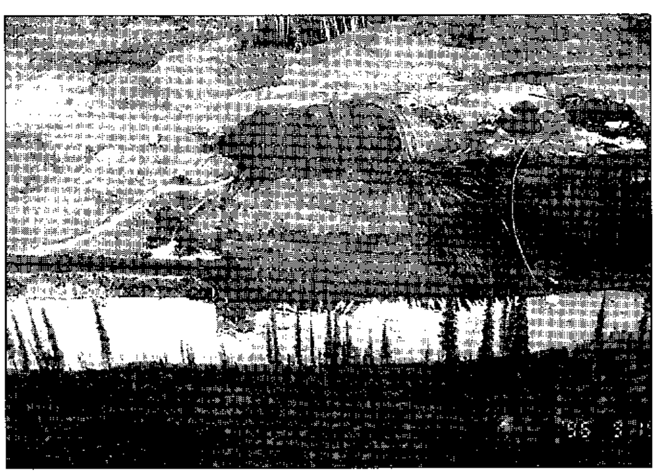

***Figure** 8. Land-based New Zealand trommel wash plant being used on a point bar. D. McBirney, Lower Indian River.*

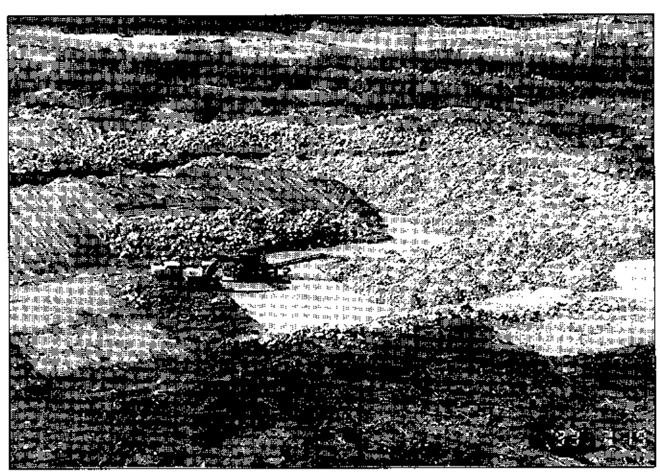

***Figure** 9. View of floating trommel wash plant. John Fischer, Gladstone Creek.*

WASH PLANTS
"WHAT,? MAKE MY LIFE EASIER!"

Have a lay–flat hose between your rigid pipe line (preferably aluminum) and the wash plant for ease of movement. Keep away from a wash plant that requires a major undertaking to move, set up, or level, and requires a great effort to build ramps. Pay material and tailings should not have to be hauled great distances. It does not pay to move material twice especially if it's low grade. Recontour in place where possible.

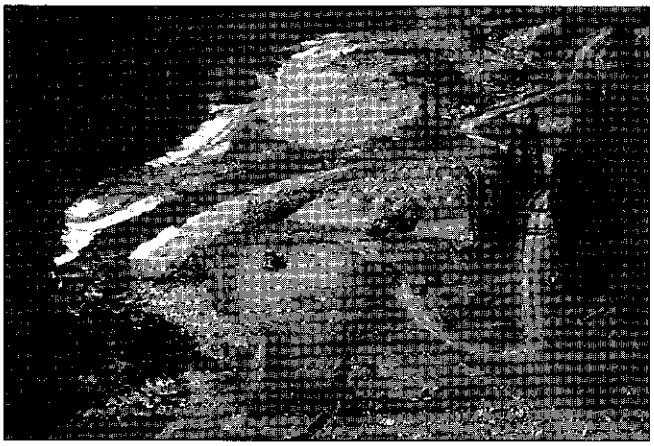

Figure 10. *Overview of floating trommel wash plant. Al Dendys, Gladstone Creek*

WATER PUMPS
"WHICH ONE WILL DO THE JOB?"

Purchasing the right pump is important! A poorly selected pump may fail or will not operate properly under conditions for which they were not originally designed, resulting in frequent repairs, clogged impellers, and higher fuel costs.

It all comes down to: how many gallons per minute are needed; how high the pump is located above the pump pond; how high the water is to be lifted (head) after it exits the pump; the length of pipe to be used; and the amount of power required for the specific use. The main pumps used in the placer industry are: centrifugal single, double or self-priming, submersible, diaphragm and double diaphragm models.

A centrifugal pump works on the principal of centrifugal action of rotating impellers, blades or vanes. Self priming centrifugal pumps deliver relatively high discharge heads, and do not need a foot valve. The pump location must be reasonably close to the water level, and the pump can be used with different drives.

Centrifugal pumps are generally single stage. Pumps in series are sometimes used where additional head is required. Foot valves are generally needed. Trash centrifugal pumps can handle large solids, pump heavy muck, and have an easy-clean out-port. They do not deliver high discharge head, but deliver decent volumes and normally require a check valve.

Submersible pumps with electric motors are generally low-to high-

Figure 11. *Mining of stream gravels on Cottoneva Creek (M. Fuerstner)*

flow with low head, and are usually more expensive to maintain. Diaphragm pumps generally have moderate flow with a low head, and have good suction lifts that handle muck and general debris.

FREE ADVICE

Explore the Yukon and visit the placer creeks for a couple of seasons before you invest. See if it's all you thought it would be! Many a miner will tell you it's not an easy ride but if you make it, it's well worth the price of admission.

The miners are a friendly bunch most of the time, and are our best resource. Remember: Network Network Network!!!

ACKNOWLEDGEMENTS

This text was edited by Rob F. Thomson, and reviewed by W.P. LeBarge and C.F. Roots.

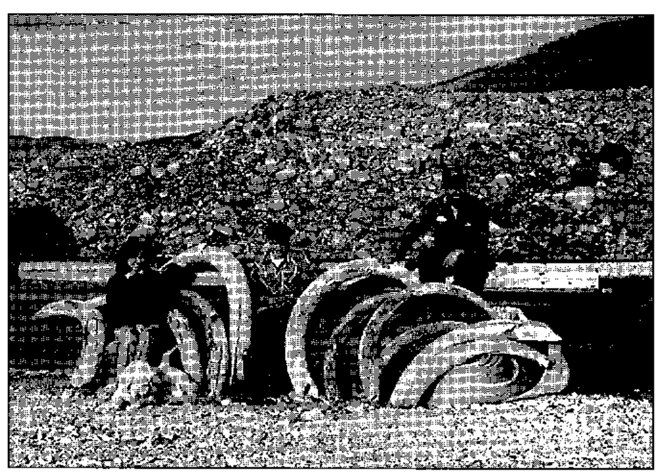

Figure 12. *Ten mammoth tusks recovered from placer operation. Elaine, Hayden and Bruce Cowan, Quartz Creek.*

Assisted Revegetation of Fine-grained Tailings at Whitehorse Copper Mine: A Pilot Project, 1994-1996[1]

D B. Craig[2] and J. E. Craig[2]

CRAIG, D. B. AND CRAIG, J. E., 1997. Assisted Revegetation of Fine-Grained Tailings at Whitehorse Copper Mine, 1994-1996: A Pilot Project. In: LeBarge W. P. and Roots. C.F. (editors). 1997. Yukon Quaternary Geology Volume 2, Exploration and Geological Services Division, Northern Affairs Program, Yukon Region, p.49-60.

ABSTRACT

Whitehorse Copper Mine, within the city limits of Whitehorse, produced about 10 million tons of fine-grained calc-silicate tailings before its closure in 1982. The tailings, now desiccated, do not support plants although some areas have been undisturbed for more than 20 years. Barren tailings have high pH and electrical conductivity (E.C.) but are otherwise non-toxic.

The minimum requirements for sustainable plant growth are under study in a pilot project in which freely available compost from various sources was mixed with the uppermost tailings as a proto-soil. Six plots were initially treated with one dose of chemical fertilizer, regularly irrigated and protected from wind. Planted Yukon native grasses germinated and both transplanted trees and seeds in the compost survived. Grass growth was measured after 2 growing seasons and is directly related to the quantity and quality of the compost tilled into the upper 10 centimetres of the tailings. Soil texture, moisture retention and organic nutrients improved. Similar abandoned sites could benefit from the addition of readily available compost and the use of locally propagated seeds and native plants.

RÉSUMÉ

La mine de cuivre de Whitehorse, située à l'intérieur des limites municipales de la ville, a produit environ 10 millions de tonnes de déchets calco-silicatés à grain fin avant sa fermeture en 1982. Ces résidus, aujourd'hui desséchés, se caractérisent par un pH et une conductivité électrique élevés, mais ils sont par ailleurs non toxiques. Toutefois, aucune croissance de plantes pionnières n'est apparente sur ces résidus dénudés après plus de vingt ans d'abandon. Les exigences minimales pour une croissance végétale durable font l'objet d'un projet d'étude pilote amorcé en 1994. Du compost facilement disponible auprès de sources diverses a été mélangé à la couche supérieure des résidus de six parcelles afin d'y favoriser la formation d'un proto-sol. Ces parcelles ont toutes été traitées de manière uniforme avec une dose d'engrais chimique, irriguées uniformément et protégées du vent. Les herbes indigènes du Yukon qui ont été plantées ont germé, et les arbres et plantes importés qui ont été transplantés avec du compost ont survécu sur les résidus aménagés. La croissance des herbes a été mesurée après deux saisons de croissance; elle est directement fonction de la quantité et de la qualité du compost incorporé aux 10 centimètres supérieurs des résidus. On note une amélioration de la texture du sol, de la rétention d'humidité et de la qualité des nutriments organiques. Les sites abandonnés semblables pourraient également bénéficier de l'ajout de compost facilement accessible et de l'emploi de graines propagées localement et de plantes indigènes.

[1] Report originally written for project sponsors: Hudson Bay Mining and Smelting Company Limited, 1994, 1995, 1996; Yukon Chamber of Mines, 1994; Rotary Club of Whitehorse, 1995, 1996.

[2] 32 Sunset Drive North, Whitehorse, Yukon, Y1A 4M8.

INTRODUCTION

Rehabilitation of mined areas is being increasingly regarded as part of the mining cycle, just as diamond drilling is essential to the exploration stage. Deleterious site conditions such as acid drainage, arsenic in groundwater and wind-blown mineral dust were formerly ignored but are now addressed during mine planning. In addition revegetation of mine tailings is now a basic requirement of the abandonment stage (Kennedy, 1993). Nevertheless, many mining sites were closed before environmental regulations were tightened. The former Whitehorse Copper mine is one of these. This project had two aims: 1) to understand the tailings and what was needed to promote plant growth on them, and 2) in a small way to rehabilitate a dusty and unsightly dried-up tailings pond near Whitehorse with mostly volunteer contributions of material and labour. We set out to determine the minimum amount of compost and work required to revegetate the infertile tailings. Results from the first three seasons are reported here. The information is useful when considering fertilization and seeding of the entire tailings area or other sites where natural re-growth is unsuccessful.

In order to thrive, plants need sunlight, water and soil nutrients, as well as suitable conditions of pH, salinity and soil texture. Where

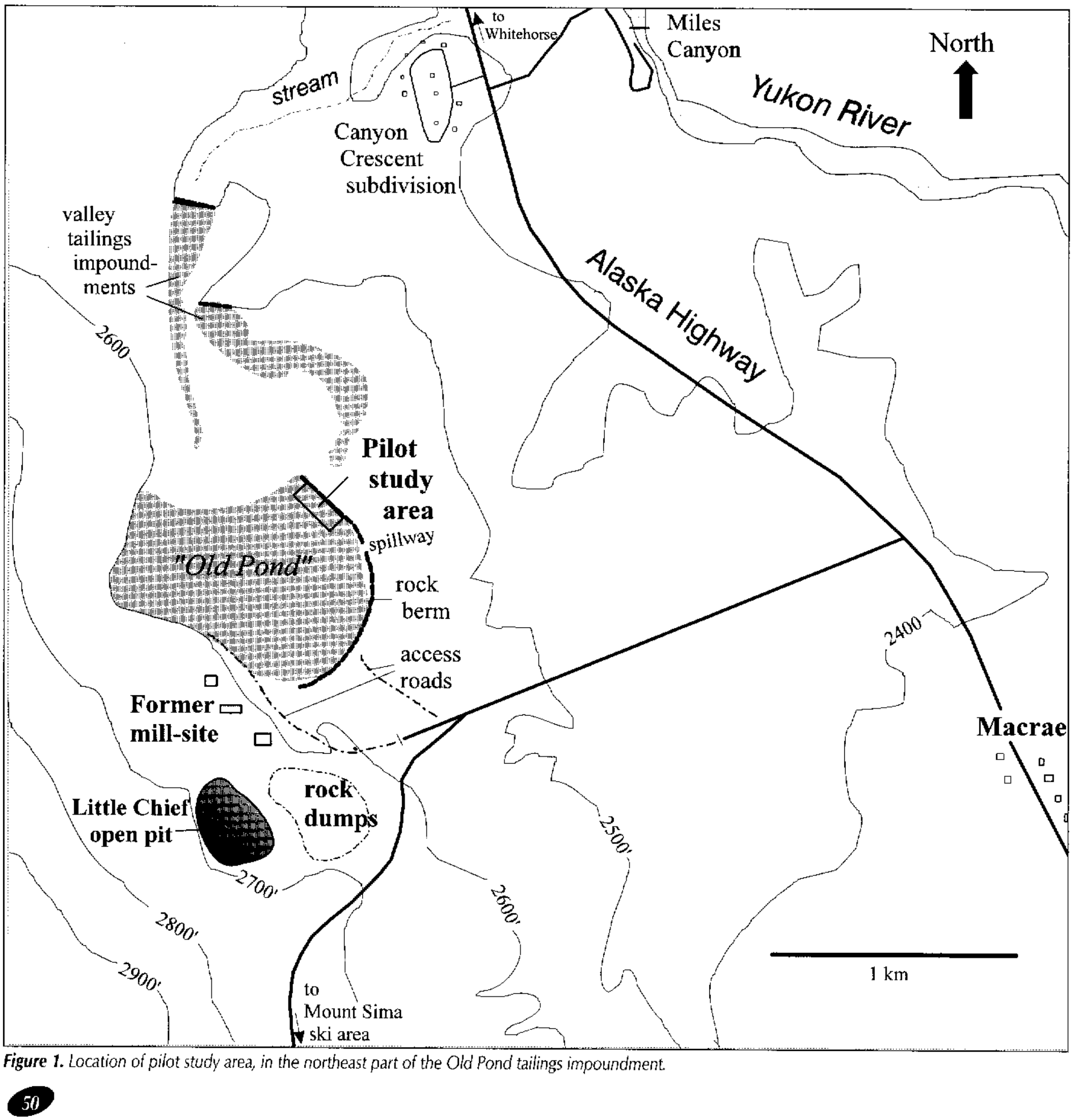

Figure 1. Location of pilot study area, in the northeast part of the Old Pond tailings impoundment.

natural revegetation does not occur such as on former tailings, at least minimum conditions must be artificially returned. Although by selective isolation one can determine conditions which impair plant growth, the complex interaction of factors including alkalinity, poor soil texture and missing organic nutrients is more difficult to quantify. Adding the right balance of nutrients and topsoil would be costly and inefficient over the long term. This project explored the feasibility of applying inexpensive compost, local water (snowmelt ponds) and mechanical tilling to promote growth. The first three years of the project, during which we overcame deleterious pH, salinity, wind erosion and poor soil texture, as well as inadequate moisture, nutrients and organic matter, are reported here. We found that many local plants thrive on prepared mine tailings, and the project will eventually discover whether these plants can survive without human assistance.

The Whitehorse Copper tailings impoundments

One of the principal ore bodies (Little Chief) and the milling facility for Whitehore Copper mines was located 10 kilometres south of downtown Whitehorse, still within the city limits. The mine exploited copper sulphide minerals in a limestone pendant (Triassic Lewes River Group) within Cretaceous granodiorite. The mine closed in 1982 after 15 years of milling, resulting in more than ten million tonnes of tailings. These were dispersed in three impoundments north of the mill: first in the "Old Pond" area (Fig. 1), subsequently infilling two Pleistocene meltwater channels that are up to 20 m deep. The area of the Old Pond is 55ha and the tailings are from 0 to about 4 m deep. The impoundments subsequently dried and remain slightly hummocky surfaces of barren grey silt and dust. The eastern perimeter of "Old Pond" and the downstream ends of the valley impoundments are blocked by berms of crushed stone.

Seepage from the tailings does not contaminate local groundwater (C. Boyd, pers. comm. 1997). The principal impact upon the surrounding area is dust predominantly blown northeast of the tailings. Dunes form leeward of the Old Pond berm, and dust clouds have been mistakenly reported as forest fire smoke to Forestry officials.

In the Old Pond area (Fig. 2) tailings range from 0 to 20 meters deep and are desiccated, locally sun-cracked except for ponds formed by melting snow which gradually dry up by August. Near the millsite are isolated thickets of willow and aspen trees rooted in high ground with only thin tailings cover. Elsewhere the surface of the Old Pond , undisturbed for more than 20 years, is almost devoid of plant cover, even near meltponds where moisture is plentiful. Some sections of berms support an impressive floral display and twenty year old trees. Growing conditions are harsh (for example wind blown tailings build up as cones of sand or silt around dandelions clumps) but plants grow everywhere except directly upon thick tailings, suggesting that these lack the right balance in soil nutrients or texture.

This site, at an elevation of 790 m on the west side of the broad Yukon River valley, has a sub-Arctic continental climate with long

Figure 2. *View northwest from the rock berm across the Old Pond showing luxuriant grass in Plot#6, the wind barrier fence (white) and barren tailings beyond. Photo taken in early July 1996, with sprinklers in operation.*

cold winters and short dry summers. Average annual precipitation is 25 to 30 cm, with half in the form of snow. The growing season is short, the average frost free period being 118 days. The Old Pond site has prevailing southwesterly winds. A pilot study area was chosen at the northeast edge of the Old Pond where significant wind erosion was identified in the abandonment plan; (Gadsby, 1992). Thus the study plots are not sheltered naturally. Any revegetative success will serve to reduce the migration of wind-blown tailings.

Nature of the tailings

Tailings particles are milled limestone, granodiorite and calc-silicate metamorphic rock, ground to fine sand- or silt-size (minus 150 screen mesh or minus 0.1 mm). The minor amount of contained sulphide minerals is buffered by abundant limestone with which they are mixed. There is little clay-size fraction and the dry particles are not cohesive. Mineral salt crusts, crumbly and up to 1 cm thick (Fig. 3), indicate where evaporation is highest and tailings have a high proportion of soluble minerals. No specific toxic elements or compounds are present. Manganese is the

Figure 3. *Cracks in plot# 2 (right side; no compost treatment), and fewer cracks in Plot #3 (left side; with sawdust treatment), photographed in 1996.*

only metal slightly higher than background stream sediments of the region (Gadsby; 1992). Snow meltwater, ponded atop the tailings from May until late July, is safe to drink. The tailings are not an immediate environmental hazard, merely an eyesore.

The following aspects of the tailings limit plant growth:

- high alkalinity,
- high salinity,
- a lack of soil nutrients (including organics),
- poor soil texture,
- wind erosion, and
- moisture.

ALKALINITY

The pH of the wet tailings is approximately 9.3; too alkaline for the growth of all but the most alkaline-tolerant plants. The abundant pulverised carbonate rock easily neutralize acid produced by any sulphides remaining in the tailings after milling. The environmental problem at Whitehorse Copper contrasts with that at most base metal mines where acid is generated by exposed waste rock dumps and tailings.

SALINITY

The electrical conductivity (E.C.) is a measure of the salinity (Overcash and Pal, 1979). Below 2.0 mmhos/cm is best for plant growth; between 2 and 4 mmhos/cm is cautiously acceptable and above 4 mmhos/cm is generally toxic. Samples of the evaporite crust are greater than 4 mmhos/cm (Appendix 2)

Since the tailings consist of finely ground rock, nitrogen, a major essential plant nutrient, is lacking. Phosphorus, potassium and sulphur, however, are all present although they may not be available to the plants for other reasons such as the high pH inhibiting the uptake of potassium. The tailings are lacking in organic matter and normal soil organisms such as bacteria, moulds, fungi, worms, mites and insects are absent.

EVAPORITES

On some parts of the tailings, water, having moved downward, dissolves soluble constituents and then percolates upwards to the surface by capillary action and evaporates, leaving a light grey to white, hard encrustation, largely calcium carbonate. This material, both texturally and compositionally, is a poor growth medium, having a strong surface crust and extremely high salinity.

SOIL TEXTURE

The tailings are fine sand- to silt-size particles (0.1 mm), tightly packed and non-cohesive. In their usual packed state the tailings contain little air and have a high density which may limit root growth.

WIND EROSION

On the Old Pond site wind erodes fine-grained tailings from some areas and deposits it leeward of obstructions. Dunes are up to 1 m deep, and a prograding apron smothers the rock berm downwind of the pilot study area. Furthermore, the sharp-edged fragments driven by the wind may abrade stems and leaves of newly germinated shoots.

WATER

Unvegetated tailings quickly dry out to a depth of several centimetres, although they are generally moist at greater depth. Limited permeability between pores, or excessive permeability in desiccation cracks result in insufficient moisture availability to plants; however this is probably not a strong inhibition to growth.

METHODS

A 0.9 hectare site, 180 m by 50 m, was selected on the east side of the Old Pond for the experimental plots. The area is subject to strong westerly winds and prior to the study the surface had patches of wind ripples and no vegetation. The adjacent bermis 1.5 m above the tailings, and 15 m higher than the forest floor to the northeast. Built of rock rip-rap and gravel, the berm supports a luxuriant verge of dandelion, yarrow, fireweed, arabis and alkali grass. Apparently the composition and texture of tailings, rather than the site itself, inhibits growth.

The project had five elements: 1) preparation of compost from different types of discarded organic material, 2) protection of the site from wind, 3) devising a temporary irrigation system, 4)application of six different compost treatments to separate plots, and 5) experimentation with various plant species.

Preparation of compost:

In April and May of 1994 debris from suburban yards and landscaping as well as horse manure were arranged in windrows 2 m high and 3 m wide along the berm and periodically dampened, following recommendations in Minnich et al. (1979). The interior of the windrows heated to 60°C due to microbial activity, became dark brown or black, and shrank in volume. Mites and tiny organisms were plentiful. The windrows were aerated and mixed weekly with a tractor-mounted front-end loader and dampened again. Through April and May the windrows were covered with clear polyethylene . By early summer a quality agricultural compost was produced (added to plot #6). Another compost was made from fresh green grass lawn clippings in June. These were turned weekly, composted quickly. A third compost was started in August. It did not achieve a black humus condition due to lack of water and insufficient time for bacterial action. The partly decomposed compost was added to plot 5.

Protection from wind

Wind erosion and wind-blown particles quickly damage young shoots. The project site was first isolated by a fence constructed of plastic mesh over metal and plastic chain link that acted as a 1.3 m high wind break. An effort to provide long term protection consisted of transplanting 75 dormant trees or shrubs, representing 11 species, from the edge of nearby forest to inside the barrier fence. The trees, up to 4 m tall, were transplanted by tractor-mounted tree spade and set at three metre intervals and stakes

Figure 4. Raspberry cane in the trench separating the berm (right) from composted tailings (left).

with gardeners tape, Transplants were sprayed with antidessicant to prevent needles and bark from drying out.

Furthermore, raspberry canes and willow plantedin a trench along the east side of the site (Fig. 4) also act as a wind barrier.

Irrigation system

Until a thriving organic cover is in place, plants will not grow on dry substrate without frequent watering. For this project water was pumped from nearby ephemeral ponds of snowmelt on the old tailings. Initially water was stored in a 2500 litre tank atop a tower seven metres tall as well as in 200 l barrels and a 2500 l tub, then distributed to the growth plots by hand-held hose. In subsequent summers some 109 million litres was directly pumped from the ponds into pipes and spray nozzles (Fig. 5; details of the system in Craig, 1996). Trees at the perimeter were watered with hoses connected to the irrigation system.

Plots with different compost treatments

Part of the project site was divided into six strips, each 50 m long and of appropriate width (Fig.5), to which compost was applied as follows:

- **Plot #1**: Grass thatching and year-old landscaping waste (shrub prunings, etc.), partly composted in the windrow and roto-tilled into the upper 12 cm of tailings.
- **Plot #2**: Barren tailings, rototilled to 15-20 cm depth.
- **Plot #3**: Spruce/pine sawdust, 5-10 cm thick, rototilled into the upper 12 cm of the tailings.
- **Plot #4**: Spruce/pine sawdust mixed with lawn clippings, 5-10 cm thick, rototilled into the top 10 cm of tailings.
- **Plot #5:** Partly decomposed compost from the windrow, 2-4 cm thick, rototilled into top 15 cm of tailings.
- **Plot #6**: Fully decomposed compost 10-15 cm thick, rototilled into top 10 cm of tailings.

Plot #2, to which no compost was added, was the control plot for comparison with composted plots.

Prior to seeding commercial nitrogen fertilizer (ammonium sulphate) was uniformly spread over all plots at a rate of 150 kg/ha. The composition was 34% nitrogen and 60% potassium (potash). This application added nitrogen, an essential nutrient, and lowered the alkalinity. Tailings contain sufficient potassium for growth but may be unavailable to plants in a high pH environment.

Seeding

Plots were then uniformly seeded with a mixture of native Yukon graminoids (grasses), as well as Bering sea hairgrass (Deschampsia caespitosa), an alkaline-tolerant species developed in Alaska. Details of seeding and composition are summarized in the appendix and detailed in Craig (1994).

Some native shrubs, forbs and wild annual flowers arrived with the root bulb of trees transplanted with the tree spade. They grew as a tiny garden around the trunk of the larger tree in its new, less hospitable setting.

Raspberry cane representing a wild and domestic cross came from a local garden. Strong rooted weeds removed from domestic gardens were replanted, along with sod scraps in small plots. Some non-native flowers, including poppies, pansies, violas and Shasta daisies, arrived accidentally, probably as part of lawn compost or sods.

A hillock at the southwest corner of the study area was intentionally layered with a 10 cm thickness of weathered coniferous bark chips Several holes 0.5 m deep were dug and backfilled with un-composted leaves, grass cuttings and coarse mineral soil. Seedling tree were planted in these holes in the fall of the first year.

Results

We observed the growth, changes in surface texture, and analyzed the composition of the substrate. Twelve samples were taken from the plots on August 2, 1996 and tested for soil quality (Table 1). From the most prolific plots, grass was clipped and weighed to obtain quantitative results (Table 2). Most transplanted trees and shrubs around the border of the study area have taken root. We also noted dramatic increase in use of this new oasis by birds, insects and mammals.

Reduction of alkalinity and salinity

Added organic material became acidic upon decomposition and when mixed with tailings reduced the pH. The electrical conductivity of tailings, typically in the 'caution' range, was lowered to 1-2 mmhos/cm in well composted, deeply rototilled tailings. Evaporite crusts persisted in unvegetated patches of most plots and were perhaps exacerbated by frequent watering. Reading higher than 4 mmhos/cm were discovered in some compost made from lawn clippings, indicating large doses of chemical fertilizer (spread on lawns prior to clipping).

Addition of soil nutrients

Many inorganic nutrients are already present, and the chemical fertilizer provided the needed nitrogen. Organic nutrients, however,

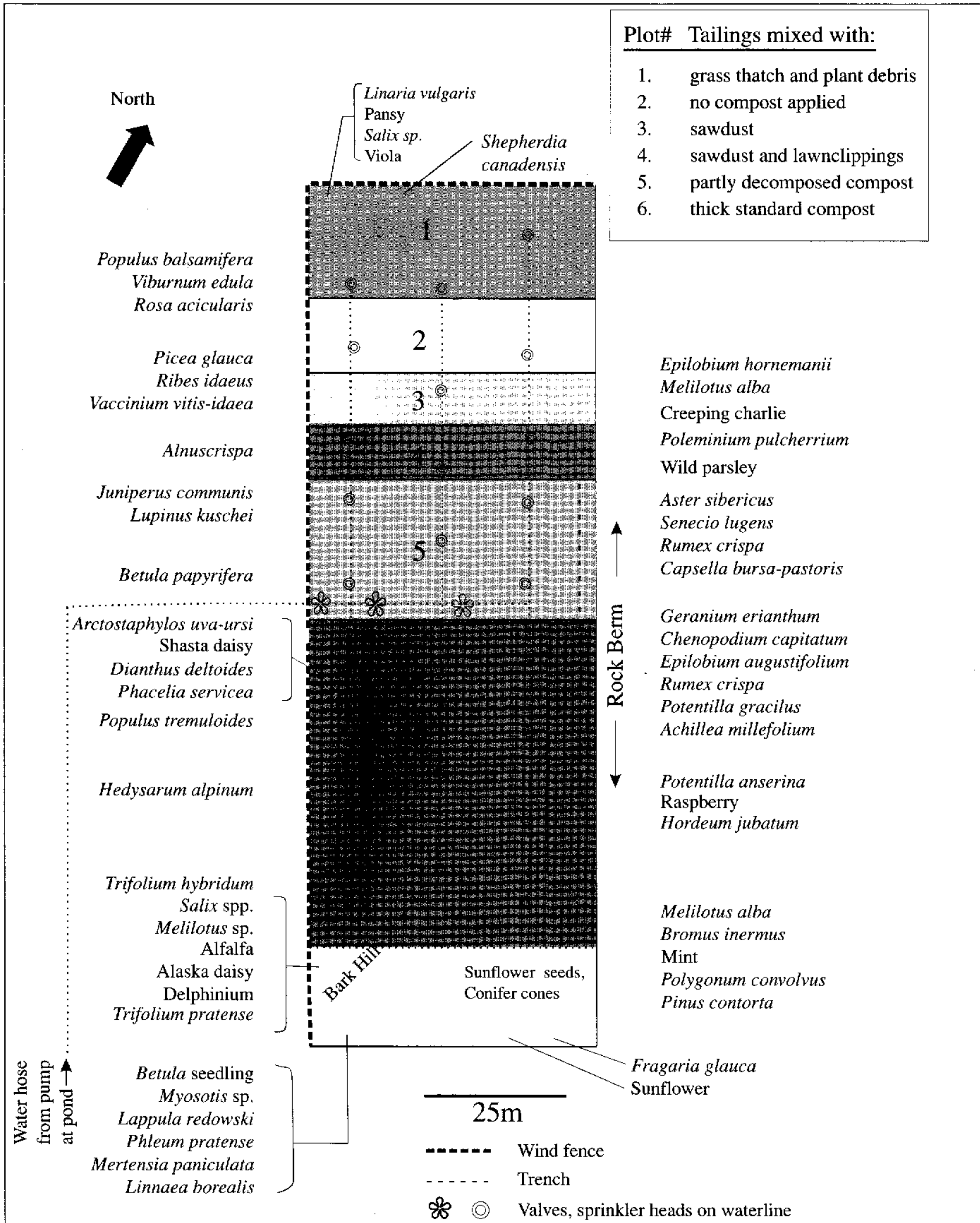

Figure 5. *Pilot study area showing experimental plots (numbered; shading proportional to the amount of compost added), irrigation pipes (dotted lines) and plant species around perimeter (identified with Porsild, 1979; Mackinnon et al. 1992).*

Figure 6. Modest growth and barren evaporite crust on plot #3.

are almost completely lacking in untreated tailings. The addition of rich compost, with its attendant micro-organisms, resolved this deficiency. Furthermore, the organic material retains moisture.

Plant growth

The following observations in August 1996 reflect two seasons of grass growth in the six test plots.

Plot 1. (grass thatching and landscape wastes partially decomposed on the windrow)

The growth of grass was uneven and modest. In contrast, abundant growth occurred along the northern edge of the plot, where an initial compost windrow had been located. Compost leachate may have drained into the underlying tailings, enriching plant growth. Furthermore, the abundant grass may well have benefited from nitrogen-fixing bacteria nodules on rootlets of the Shepherdia bushes planted along the margin (Fig. 5) .

Plot 2 (control; no compost)

Without organic enhancement and despite fertilizer, tilling, irrigation and seed, there was zero growth. Evaporate crusts developed (Fig. 3) similar to untreated areas of the Old Pond, and irrigation water rapidly drained into dessication cracks. After one year the plot resembled the original plot before the reclamation effort began.

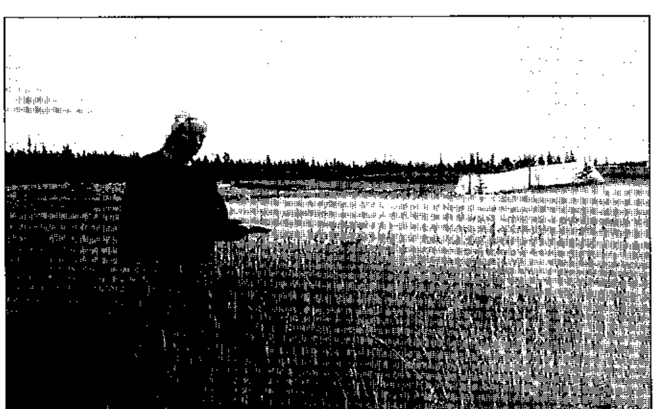

Figure 7. Dense growth (to 80 cm height) on plot #6

Plot 3. (sawdust added)

Spruce and pine sawdust rototilled into tailings produced poor growth. About 5% of the seed germinated, producing stunted grasses to 10 cm high. A textural change was apparent, however. A crumbly texture of the plot contrasted with the caked character of the control plot. No cracks developed and irrigation water was retained in the upper few centimetres (Fig. 6).

Plot 4. (sawdust and green grass)

Spruce and pine sawdust with grass clippings were rototilled into the tailings. Plants grew well, showing sporadic but locally robust growth to 25 centimetres. Although not yet a soil, the texture was more friable than barren tailings. The pH was 8.7, which is acceptable, and E.C. was 3.8 mmhos/cm which is marginal. A 0.5 square-metre area was clipped and the yield calculated to be 449 kg/hg (Table 2), suitable for wildlife.

Plot 5. (partially composted landscaping waste, 2-4 cm thick)

Plant growth was uneven and stunted. The plot had areas of evaporite crust. Evidently the compost was too little or insufficiently developed to provide good growth.

Plot 6. (standard compost 10-15 cm thick)

This plot experienced luxuriant growth over 70% of the area. The planted grass produced dense growth to 80 cm (Fig. 7). In 1995 the alkali grass was the most common gramminoid; in 1996 this growth was overshadowed by wheatgrass, bluegrass and fescue, a normal succession. The roots on one wheatgrass plant, 80 cm tall, were 12 cm long (Fig. 8). Seeds brought in with the landscaping waste germinated and added fireweed, dandelion, lamb's quarter, clover, daisies and delphinium.

Two 0.5 square-metre areas in plot #6 were clipped to estimate forage yield (Table 2). The dried grass clippings from an area of average growth weighed 2390 g (7410 kg/ha), equivalent of wildlife foraging pasture. The clippings from an area of heavy growth weighed 4100 g (12 980 kg/ha), comparable to modest forage crops on agricultural land.

PERIMETER

The perimeter belt of trees, planted as a wind break, survived the transplant procedure and put out new growth (Craig, 1995). The aspen and willow were not as fully leafed out or as robust appearing as those in nearby forest which had not been disturbed. The conifers, both spruce and pine, put out new leaders for 1995 and most of the pines set cones. The conifers were not as vigorous as the undisturbed trees. Only one tree with a badly cut root perished in the first summer (1995).

Also notable is the variety of seedling trees, grasses, shrubs and forbs livingz undisturbed around the transplant root ball. Thus, hundreds of plants, representing 20 species, were also transplanted.

In 1996, five of the conifers 4 or 5 meters tall died. Two of the tall poplars and one tall willow also grew poorly and were cut back.

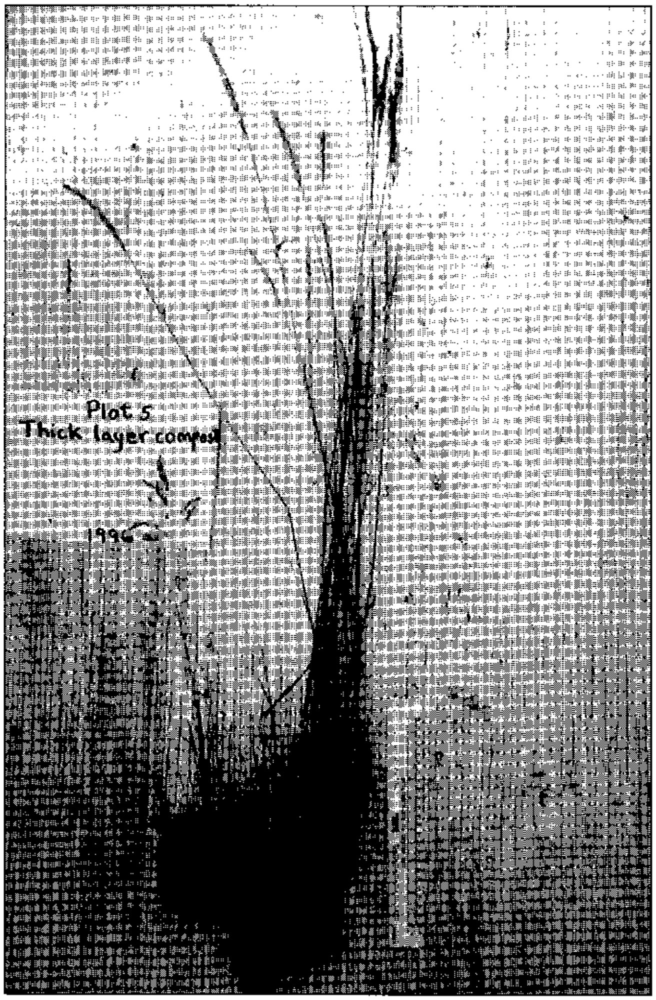

Figure 8. *Organic soil developed among roots of Wheatgrass where a thin layer of compost was mixed with tailings (plot #6). White scale bar is 15 cm*

East-side trenches had good growth of the raspberry canes and weeds transplanted from Yukon College in 1995. The raspberries set fruit and these were eaten by birds in 1995. In 1996, no irrigation was provided to the trenches resulting in stunted plants. The raspberry canes were short and the berries small. Grasses and poppies were present but stunted. Only a few willows survived. Seedling birch and raspberry were noted in 1996.

On the bark hill, seedlings planted in mineral soil and yard wastes, had some mortality. Sweet clover seed, which was dormant in the bark pile, germinated.

Sod on bare tailings had non-uniform growth depending on the species of grass and the state of health of the sod. Sod from the Sodbuster Farm seemed to be healthy for two summers. Sod from some gardens harboured other plants which have grown. Some sod has died but weeds have grown on the dead sod.

Although efforts have concentrated on re-establishment of flora, the improved vegetative cover and available bird perches have enticed animals as well. Field mice nest in the new grass. Ladybugs, aphids, grasshoppers, wasps, bees, butterflies and

Figure 9. *Goose tracks among patchy grass in an area of plot #6 previously covered by meltwater.*

smaller insects flourish in the shrubs. Lapland longspurs, Canada geese and ducks visit the tailings site during spring migration (Fig. 9) and bluebirds, kildeer and swallows may be seen throughout the summer. Tracks or sightings of bear, moose and mule deer were recorded.

CONCLUSIONS

- Rototilled compost can produce grass on formerly barren tailings when protection from wind and adequate moisture are supplied for several growing seasons.The need for care is greatest during the first season. Eventually plant growth and decay will provide necessary soil nutrients and moisture retention for continued vegetative growth.
- The plot receiving the most compost grew best. Grass in plot #6 was the highest and most consistent in coverage.
- The objective in this pilot study however, was to determine the least amount of compost that needs to be added to barren tailings to produce sustainable vegetative cover. In this respect plot #4, to which composted grass and sawdust were added, provided the minimum acceptable growth, based upon two growing seasons. Long term success (i.e. without irrigation) remains to be seen, but this plot, as are all those with greater amounts of compost, appear to be developing organic soil.
- Addition of compost reduces salinity, increases moisture retention and provides habitat for soil organisms. The organic nitrogen introduced by compost is less vulnerable to leaching than is inorganic fertilizer.
- Alkali grass acts as a nurse crop for other grass species.
- The response during the 1996 growing season was similar to that of 1995. The alkali grasses in Plot 6, which grew in 1995 died down to add to the thickness of organic matter. Compost additions to the tailings reduced the high level pH, but those which contained a large amount of highly fertilised green grass lawn cuttings also raised the E.C. level;. Springtime lawn thatchings, assorted conifer needles and cones, bark and vegetable garden wastes did not raise the E.C. levels.

Table 1. *Agricultural analysis of soil collected in the study plots and adjacent areas. Analysed at Norwest Laboratories, Edmonton, Alberta, August 1996.*

Plot#	Sample #	pH	E.C.	N	P	K (Potash)	S
			mmhos/cm	(Estimated available lbs./acre)			
Plot #1 (Landscaper's waste)							
	#1: near Shepherdia	8	2.6	4	80	526	80
	#2: near pine	8.6	2	4	30	458	80
	#3: landscape waste	9.4	2.5	22	53	385	80
Plot # 2 (Control)							
	# 4	9.4	1.3	4	27	179	80
Plot #3 (Sawdust)							
	#5	9.3	5.9	4	22	502	80
Plot # 4 (Sawdust + grass)							
	#6	8.7	3.8	4	25	497	80
Plot # 5 (partial compost, 2 - 4 cm thick)							
	#7	8.7	7.8	52	44	919	80
Plot # 6 (Average, compost, 10 cm thick)							
	#8	8.7	1.2	20	49	409	80
(Heavy, compost, 10 cm)							
	#9	9	1.2	58	120	887	80
Bark hill:	# 10	8.9	1	4	30	151	80
Tailings, May pond,	# 11:	9.2	2.9	4	20	417	80
Sunflower + dump,	# 12	9.2	1	126	32	162	80

Table 2. *Grass yield from test plots, with extrapolated yield, August 1992 (courtesy of Department of Agriculture, Government of the Yukon.*

		Dry weight in g	Estimated Yield
Plot # 1	Clipped 0.5 square metre	118	2360 kg/ha
	Random, clipped 0.5 m	229	580 kg/ha
Plot # 2	Control; no grass to clip	0	0
Plot # 3	(Sawdust added)	3	60 kg/ha
Plot # 4	(Sawdust + grass added)	22	440 kg/ha
Plot # 5	(Partially composted, 2 to 4 cm layer)		
	random, 2 areas (0.5 m) clipped	Average 6.5	150 kg/ha
Plot # 6	(Standard compost, 10 cm)		
	Clipped, average growth	2390	7410 kg/ha
	Clipped, heavy growth	4100	12,980 kg/ha

- Bare spots from 1995 filled in with grass during the 1996 season. The 1995 evaporite patch on Plot 6 experienced plant growth in 1996. The evaporite patches on other plots are still present and contribute to the poor growth and non-uniform patterns of growth.
- Wind erosion in 1995 and 1996 was reduced
- Revegetated areas encourage birds and animals to return to formerly unproductive areas. Lady bugs, aphids, grasshoppers, wasps. bees and butterflies were among those present in 1996.

Recommendations

The pilot site:

- should be irrigated through another growing season. Assuming years of average snow accumulation, the resulting meltwater pools are probably adequate. By the end of 1997 plants may be well enough established that irrigation will no longer be required.
- A former minesite and reclamation testing ground within the city is a valuable education resource. Research by elementary, secondary and university students enhance the validity and help quantify the success of the reclamation project. Field trips and studies are welcomed.

Remainder of the tailings impoundment:

- Household organic waste and contractor's grubbings, largely directed into the Whitehorse city landfill at present, should be trucked to the Whitehorse Mine site. If a municipal compost facility were available, surface barren tailings in other parts of the Old Pond site could eventually be mixed with organic material.
- Revegetation should be expanded to other parts of the tailings, using the cost-effective conclusions of the pilot project. Small floral oases with adequate compost and early care, stand a better chance of continued survival and recolonization of surrounding area, than uniform revegetation of a single large block.
- A reliable water source is needed for more ambitious revegetation.
- A nursery specializing in native Yukon trees, shrubs, forbs and grasses should be established to provide reliable stock for reclamation effort in Yukon.

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Nine paid part-time employees worked on the site during the 1994 and 1995 growing seasons. Barbara Robertson and Diana Mulloy frequently walked out and gave valuable encouragement. They also photographed the work at the reclamation site.

University students working on their own research or courses used project information in their studies, including: Jeanne Burke (Ph.D), Ian Oostendie and Diana Watson (M.Sc), Malcohm Taggart and Alison Black (Course-work paper). Students from grade five, junior high school and grade eleven toured the site with their class teachers. Members of the Whitehorse Garden Club, Rotary Club of Whitehorse, officials from the City of Whitehorse, Association of Yukon Communities, Department of Indian and Northern Affairs Canada, Natural Resources Canada and Yukon Territorial Government visited. Tony Hill, David Murray and Randy Lamb from the Agriculture Branch, Yukon Renewable Resources provided encouragement and professional assistance. Yukon Agriculture sent soil samples to Norwest Labs, Edmonton and dried and weighed clipped grass samples.

The manuscript was reviewed by Charlie Roots.

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